FUN WITH ROPES AND SPARS

Michael S. Holmes

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Acknowledgements

I would like to thank all those who assisted me in the production of this book. The folks at the national Scouting archives in London, England, didn't quite know what to make of someone who actually wanted to search their records for old pioneering projects. The staff of the National Scouting Museum at Murray State University also were very helpful and provided me access to the papers of Greenbar Bill.

Many people sent me ideas for projects. Most I already had from other sources, but a few were really different. Those appear and are identified in the book.

Finally, I would like to thank my wife, Reva, a wonderful proofreader, for going over the text and "Ranger" Norm Yeagle, who checked all the illustrations. Ultimately, however, the responsibility for accuracy is mine alone.

A Few Words to the Reader

Dear Reader:

Welcome to the world of "wilderness engineering." The projects in this book begin with very simple structures and move to more complex efforts. Beyond that the chapters are arranged by the type of structures they contain. Some are just for fun. Some are useful. You can build most by yourself, but will need help to make others.

This is an "activity" book. You will not enjoy it unless you actually build these projects, whether as models or full-sized structures. To do that you probably will want to print whatever pages you need to use. Please feel free to do so.

I also welcome any reactions you might have to my efforts. Let me know of errors and, especially, of other projects you would like to see included in subsequent editions.

Most of all, HAVE FUN!

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CHAPTER I
GETTING STARTED

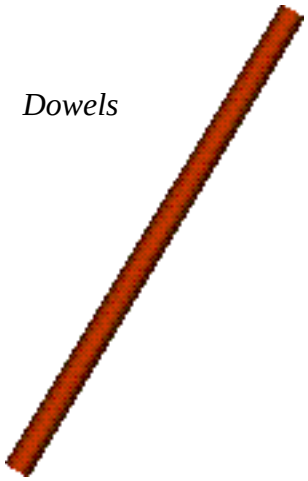
Do you like to make things? Then this book is for you. Almost all of the projects can be built with “line” and “spars.” Line can be anything from fishing line, to string to heavy rope. Spars can be small, round sticks of wood -- called dowels -- to broom handles, to tree branches or even the trunks of young trees. With string and dowels, you can make models; with rope and tree branches, you can make large, full-size, usable structures.

Fishing Line

to

Rope

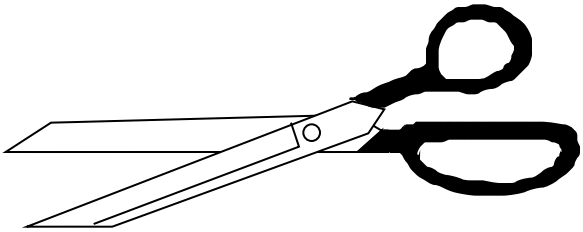
Dowels



to

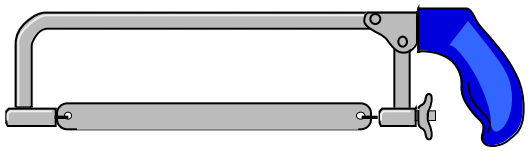
Trees or Branches

Cut to make straight pieces

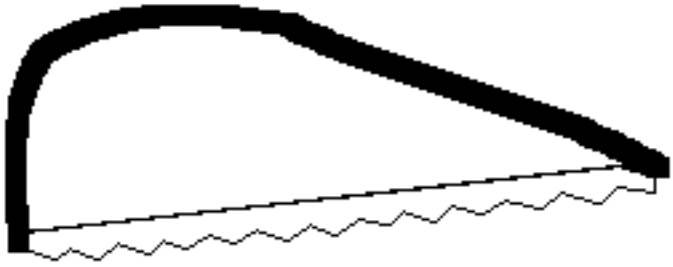


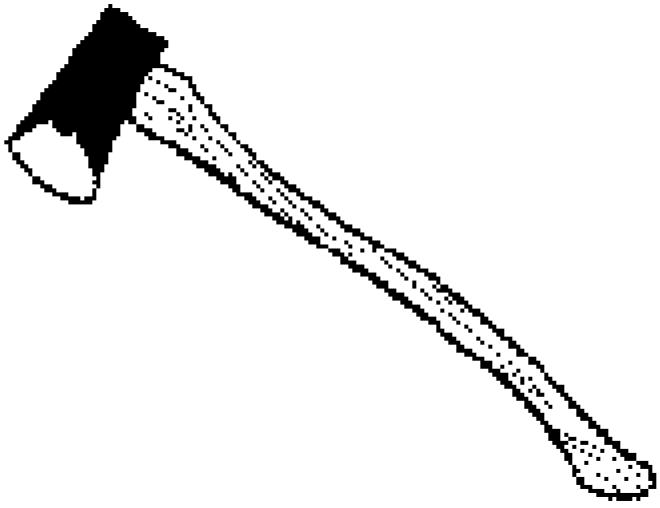
For tools, you will need scissors

and a knife to cut your line.



To cut dowels, you will need a saw. (You also might want a drill to put holes in the ends of the dowels where you will tie your line.)



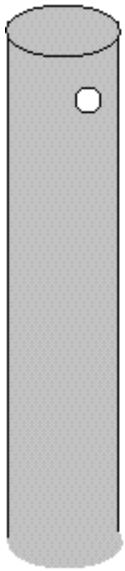


For trees and branches, use a bow saw or axe and a knife and hatchet to trim small branches and leaves.

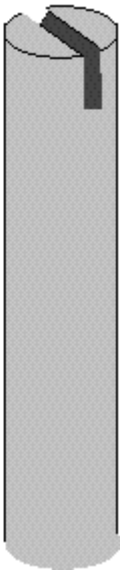
Remember not to cut living plants, unless you have permission!

That's it! There are a few other special things used in some of the projects, but mostly all you need are straight spars -- usually made of wood -- but possibly metal or plastic, some sort of line to tie the spars together and some simple tools to be able to cut your line and spars to the right length. With these things you can make almost all of the structures in this book.

Most are simple enough so you can look at the picture and see how to put the line and spars together. Some have lots of lines and spars. For these you may want to build models first, using dowels and string or dowels and rubber bands. That way you can see what they will look like before you try to make them full size.

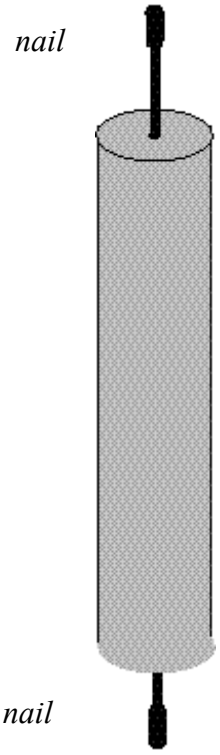


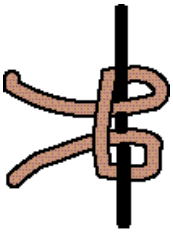
drilled hole



notched

If you use dowels and string, drill holes at the ends or notch them so it will be easier to attach the line.

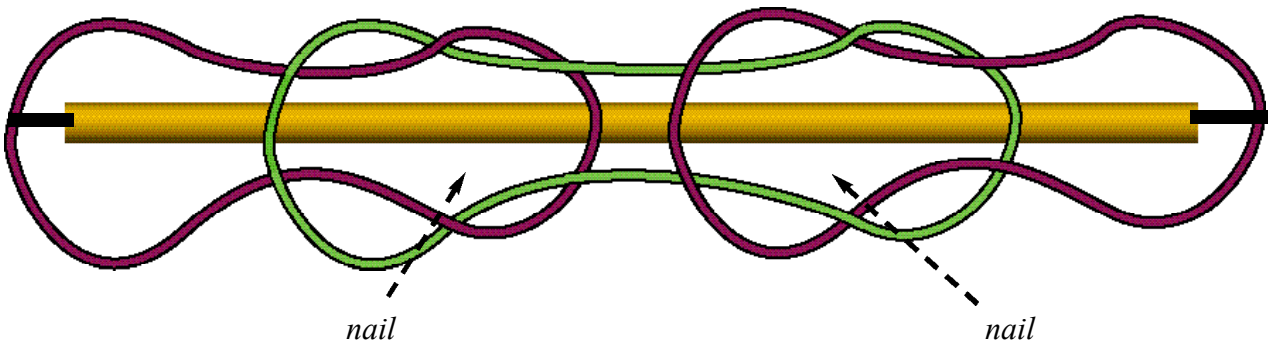




larks head

If you use rubber bands, put a brad or a small nail in each end of the dowel. (You may want to drill the dowel to keep it from splitting when you put in the nail.) Use a larks head knot to attach the rubber band to the nail.

The number of rubber bands you need depends on how many spars will be attached to them. Use one rubber band for each spar.. (If you are attaching two spars to the line on a third spar, use three rubber bands, as shown.)



Loop the rubber bands over each other to link them together. Then tie the ends around the nails. Put the nails on the other spars though the rubber bands where they come together as shown by the arrows.

Some Useful Things to Know

Rope:

When you work with rope, it is good to know certain terms.

The *standing* end of a rope does not move. Usually it is tied to something.
The *running* end of a rope is the end you work with. Normally, but not always, it is the longest end.
A *bight* is a bend in a rope.
A *loop* is a bend that is brought around until the rope crosses itself. If you hold the rope in your two hands and put your right hand over your left, you have made a *right-hand loop*. A *left-hand loop* is made by passing your left hand over your right hand.

For models, you can use string, fishing line or even rubber bands. For larger structures, especially those you will walk or climb on, you must be careful about the kind and size of rope. Synthetic ropes (nylon, etc.) are very strong, are not affected by being out in the weather and do not fray easily. However, they are slick and are hard to tie tightly to spars (particularly if the spars are store-bought or have the bark stripped off of them). Natural fiber ropes are better for lashing, but you need to take good care of them. Always check for wear and the effect of knots.

All rope has a breaking strength, which depends on the material used and the thickness (diameter). Sometimes it is printed on the package label. The stress you put on your rope should be less than one-fourth to one-sixth of its breaking strength. Also knots weaken rope, so keep that in mind when you decide what size rope you need to use.

Finally, take good care of your rope. Keep it dry and loosely coiled. If the ends start to unwind, fuse them with heat (synthetic fibers) or wrap them with string (whipping) or tape. You even can use glue or paint. A good idea, if you pre-cut your rope, is to use color-coded ends. Figure five feet for each letter in the color: Red is 15 feet (3 letters times 5 feet = 15 feet). Blue is 20 feet, black or green is 25 feet and yellow is 30 feet.

Spars:

If you buy spars (dowels) at the store, make sure that they are large enough for your project. Whether you are building models or full-scale structures, remember that longer spars must be thicker. The type of wood you use also makes a difference. Ask at your lumber yard about the weight and strength of various woods.

If you are using branches or small trees, be sure to respect the environment. Never cut living trees unless you have permission! Store-bought spars tend to have consistent breaking points. Wood you find outside, especially when it is "dead-fall" does not. Test any wood you find on the ground to make sure it is strong enough for the job. It's also a good idea to strip the bark off of your wood, especially if you plan to save it to use again. This keeps insects from attacking it.

As with rope, spars should be stored in a dry place, preferably off the ground. This is especially important for wood that is "green," because it still contains a lot of moisture.

Rope and spars that are well cared for will last a long time. However, it's always better to replace both before they are completely worn out.

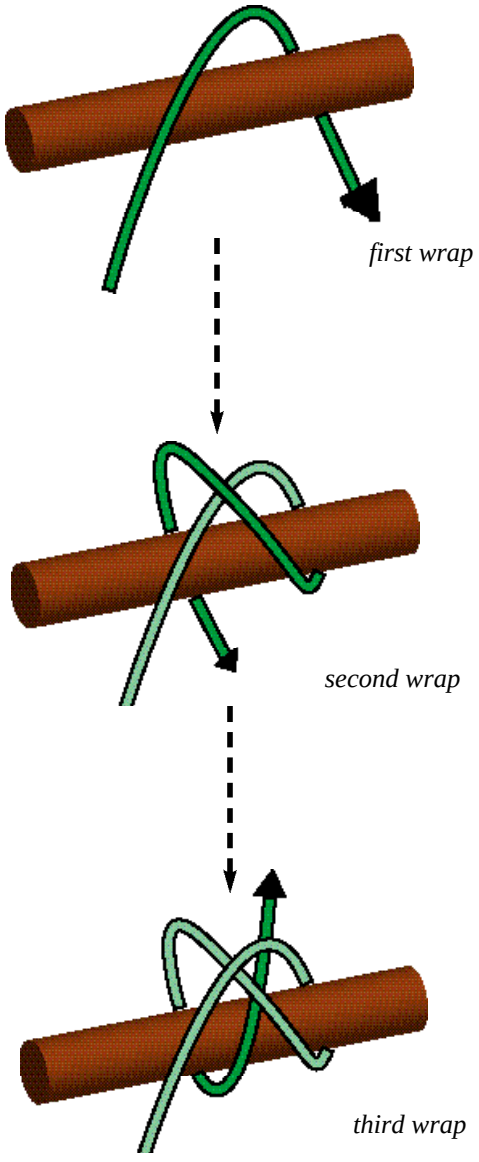
CHAPTER II
BASIC LASHINGS

Knots

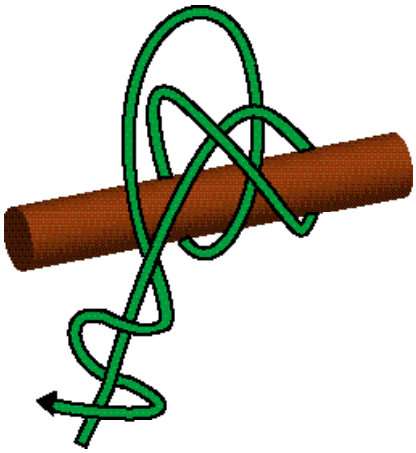
Most of the time, you will use your line to tie spars together. This is called “lashing.” There are only a few basic lashings, but from these you can make many things. All lashings begin with one of two knots — a clove hitch or a timber hitch.

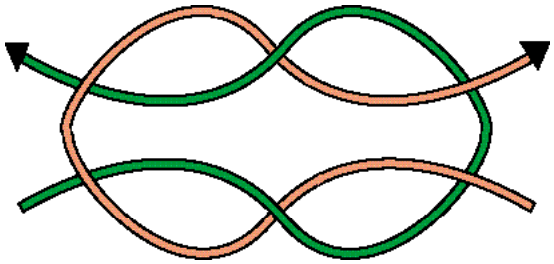
The clove hitch is made by wrapping your rope three times around the spar. The second wrap crosses the first wrap to form an “X.” The third wrap goes under the first two where they cross. The loose short (standing) end can be held in place by wrapping it around the long end — called “pig-tailing” — or by tying it to the long (running) end in a square knot.

Hint: To make your clove hitch hold better, take an extra wrap around the spar and under the “X.”



Pig-tail

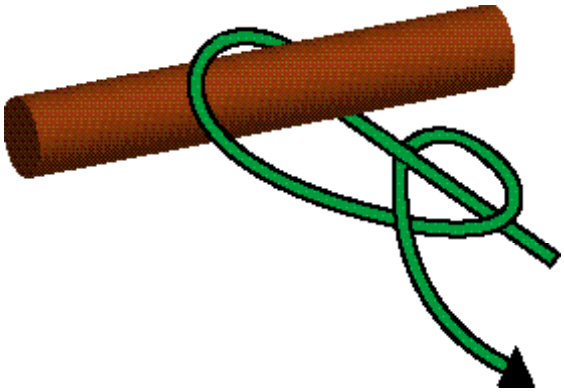




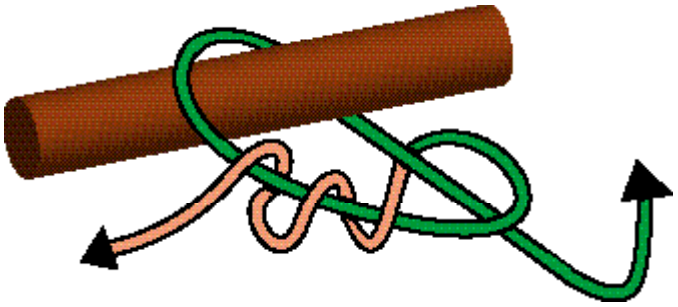
Square Knot

You also can tie the clove hitch by making two right-hand loops in your rope and then putting the first loop on top of the second loop. This way is quicker and is used when the knot is to be tied at the end of a spar.

The second knot you need to know is called the timber hitch. Begin by tying a "half hitch" around the spar. (It's just like a simple overhand knot with the long -- "standing"-- end pulled out.) Now, bring the rope back and wrap it around itself a few times. Then pull the standing end against the loop you have formed.

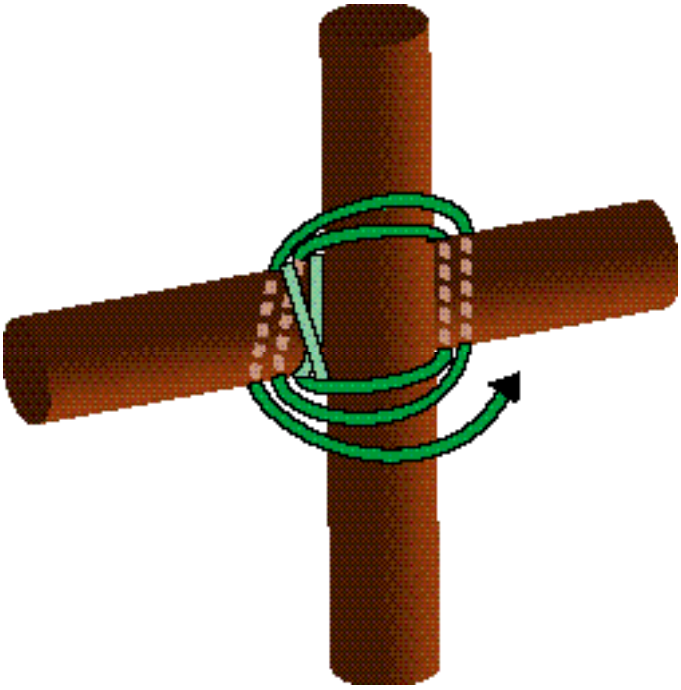


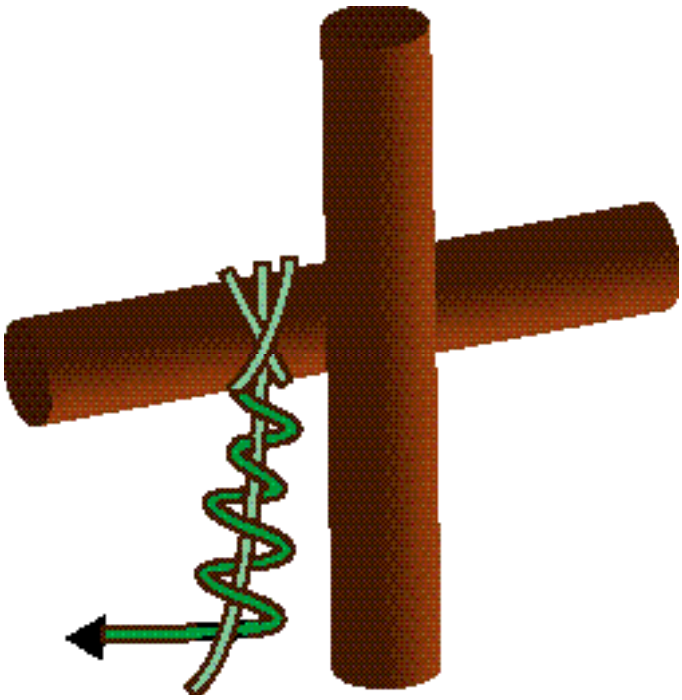
That's it! There are many more knots you can learn. Some are used for special purposes in making certain structures, but we will talk about those later. These two knots, the clove hitch and the timber hitch, are the knots we use to lash spars together.



Classical Square Lashing

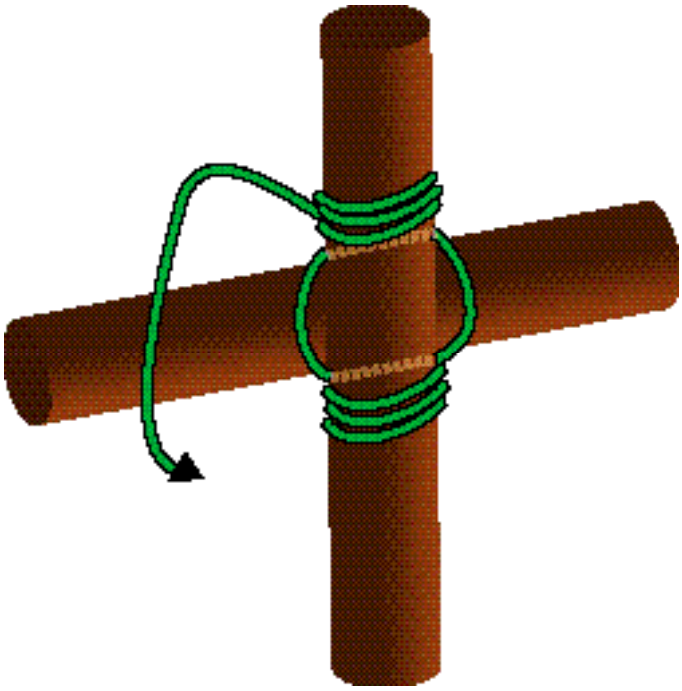
Most of the time you will use the square lashing. Start with two crossed spars. Tie a clove hitch around the vertical spar below the place where they cross. Tie off the short end using a pig-tail.





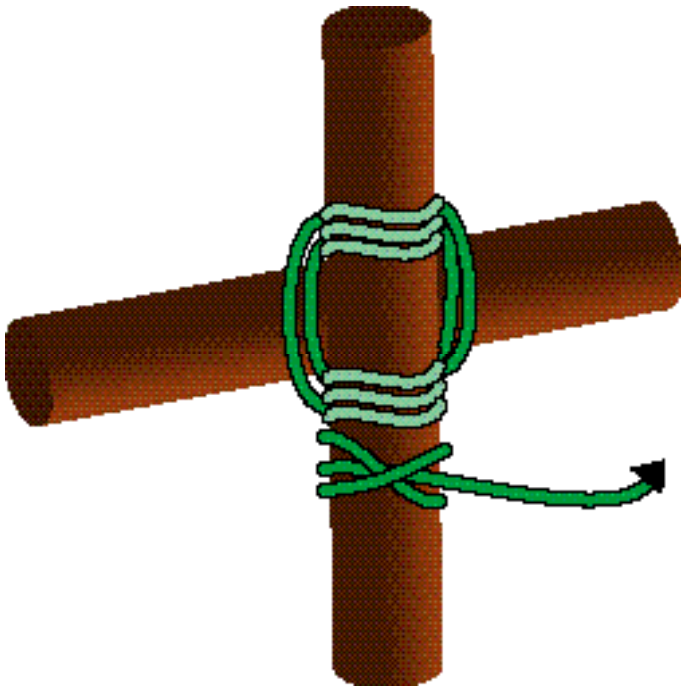
Then begin to weave the long end of the rope over and under the spars all the way around until you get back to the clove hitch. Do this twice more (for a total of three wraps).

Now wrap the rope in between the two spars, all the way around twice. This is called “frapping.” It tightens the rope so the lashing will hold the spars together securely. Complete the square lashing by tying a clove hitch on the cross-spar.



The lashing needs to be very tight. Here are some hints to help you.

1. Pull tightly as you wind the rope around the spars. To do this, wrap the rope around a small piece of wood and use that as a handle to help you pull the rope snug.
2. A clove hitch can be tightened by grabbing the entire knot and twisting it around the spar. Then pull back on the loose end. Do this in alternation on the last knot, twisting it in the direction of the loose end. You will feel it tighten.



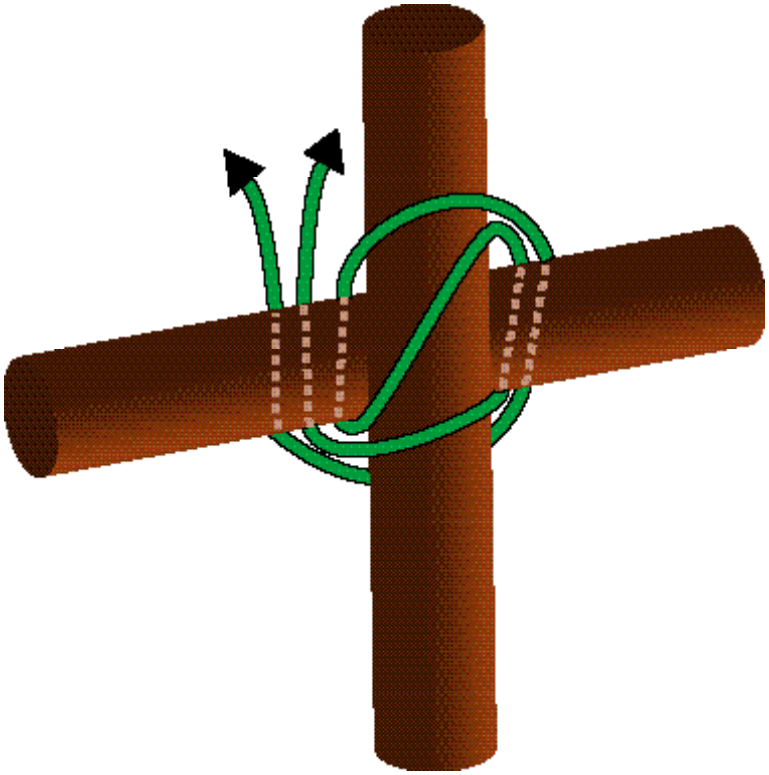
Remember, it is important to get the lashing very tight!

Since clove hitches are hard to tighten, there is another way to finish the lashing. When you begin, do not pig-tail the loose end. Leave a little extra hanging. When you finish, instead of tying another clove hitch, tie the end you have worked with and the loose end together using a square knot.

If you are lashing the two spars together while they are upright, you will need a way to keep the lashing tight as you tie it. That way the cross spar will not keep slipping down. Instead of wrapping three times and then frapping twice, you can wrap once and frap once, then wrap a second time and frap a second time -- and so on. That way the lashing will remain tight as you tie it.

Now we will take a look at different ways to tie square lashings.

Modified Square Lashings

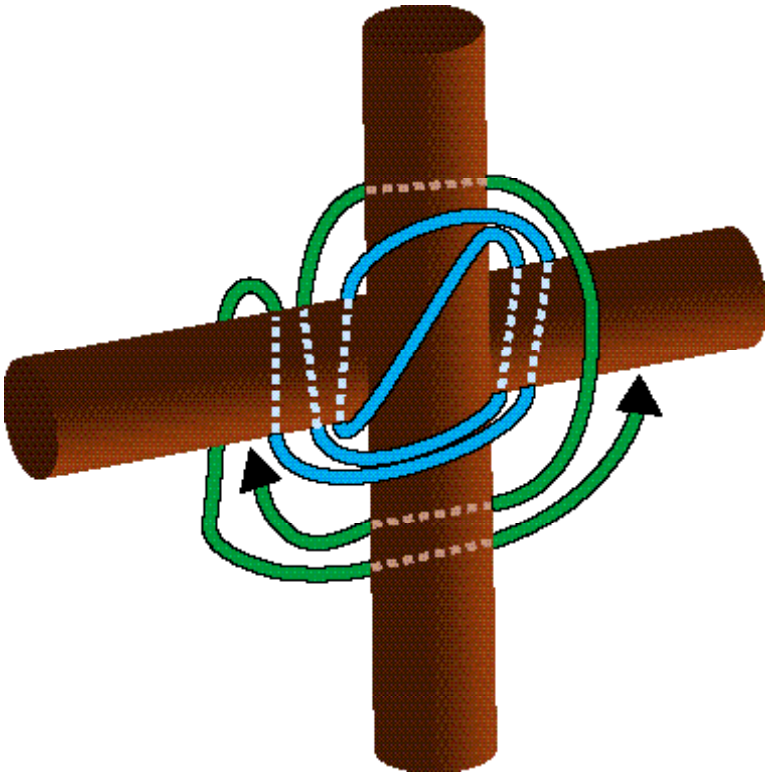


Japanese Square Lashing

Fold the rope in half and place it around one of the spars. Bring the ropes together and weave them around the spars three times.

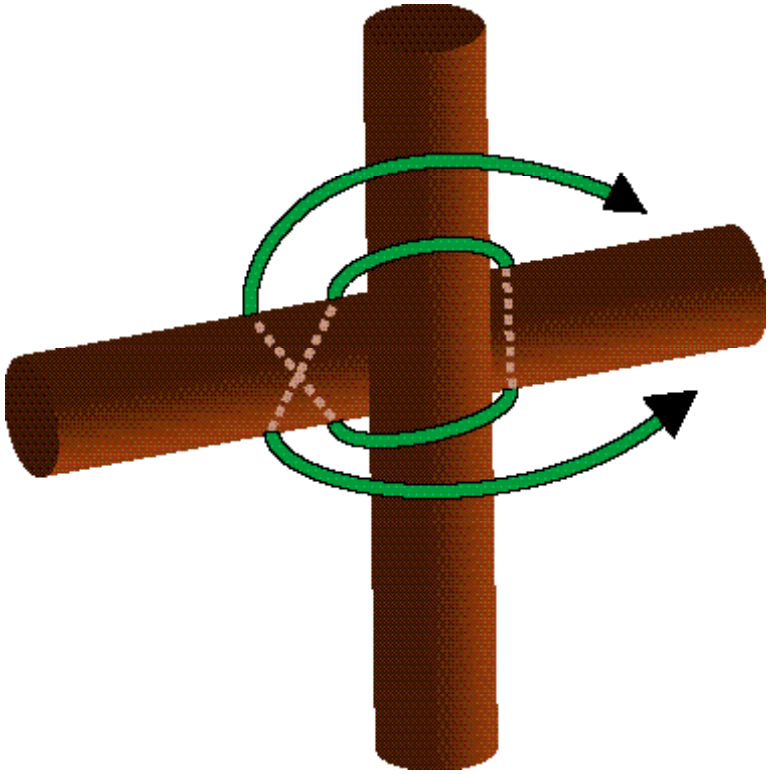
Then separate them to frap the spars. To finish the lashing, tie the loose ends of the rope into a square knot.

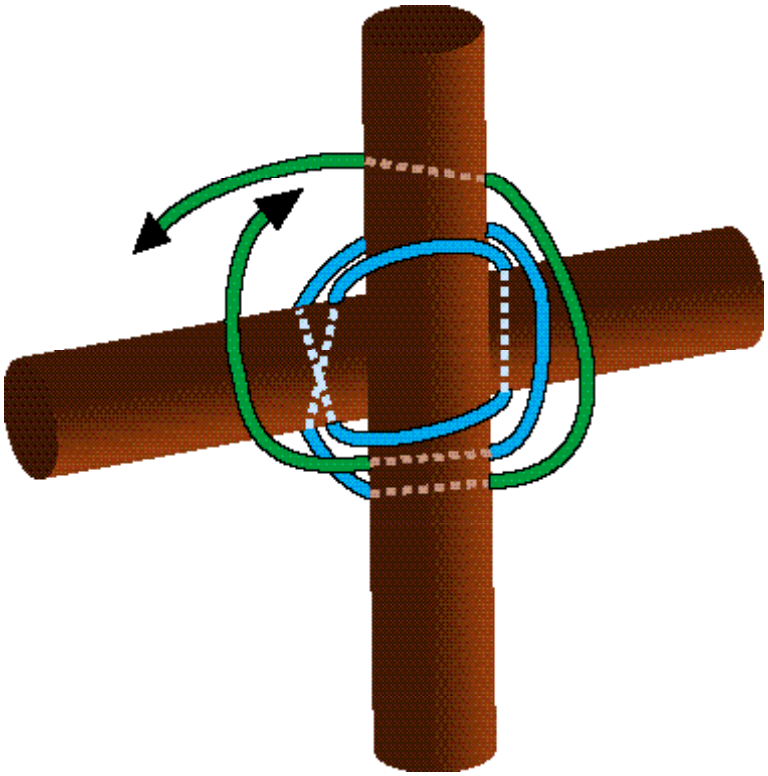
Note that the extra wraps are not shown.



Japanese Square Lashing II

Fold the rope in half and place it around one of the spars. Then separate the rope and weave each end around the two spars going in opposite directions. Go around three times.



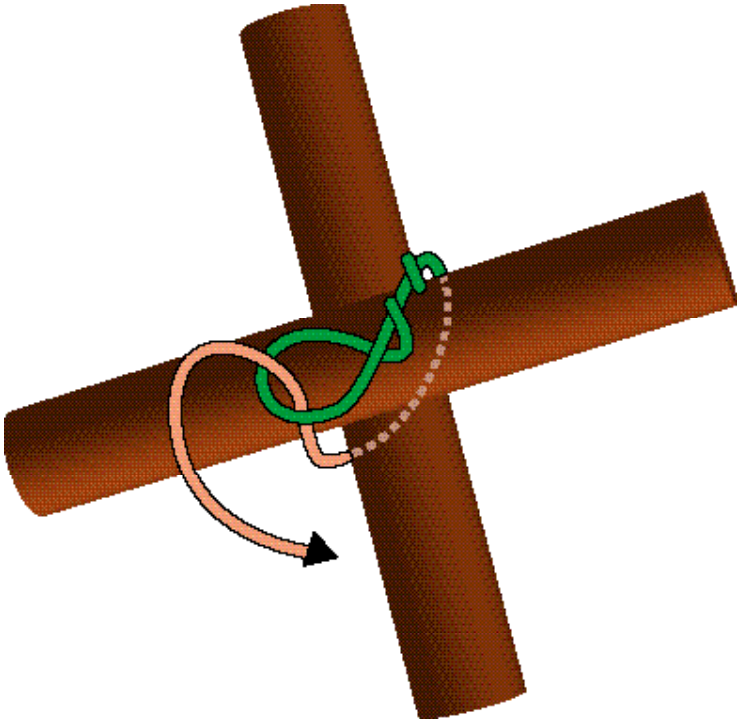


Frap the same way, and tie the ends off in a square knot.

These two lashings are quick to tie, but you must start with a rope of the correct length. (When you tie a classical square lashing, the extra rope can be cut off.) Also, these lashings are not as strong as the classical square lashing and should not be used if the joint will be under a lot of strain.

Note that the extra wraps are not shown.

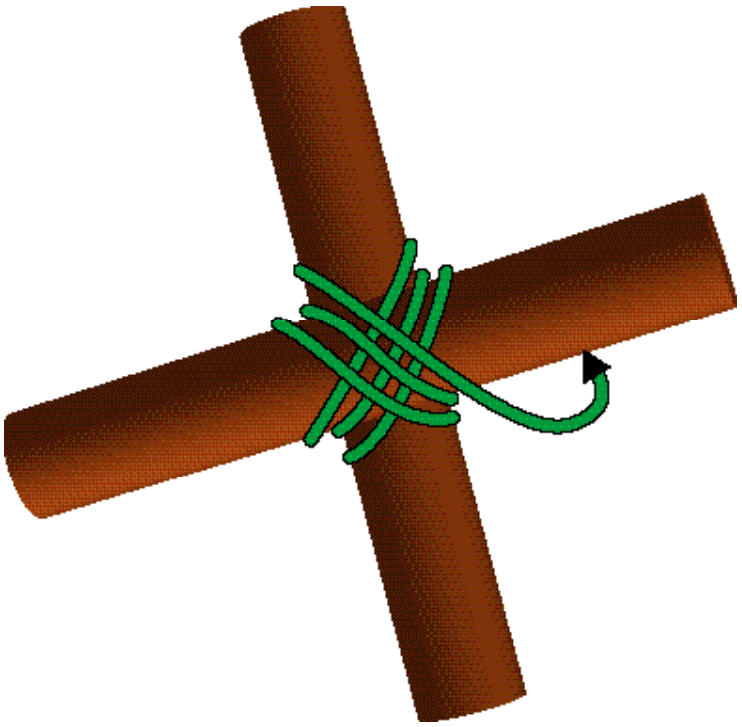
Diagonal Lashing

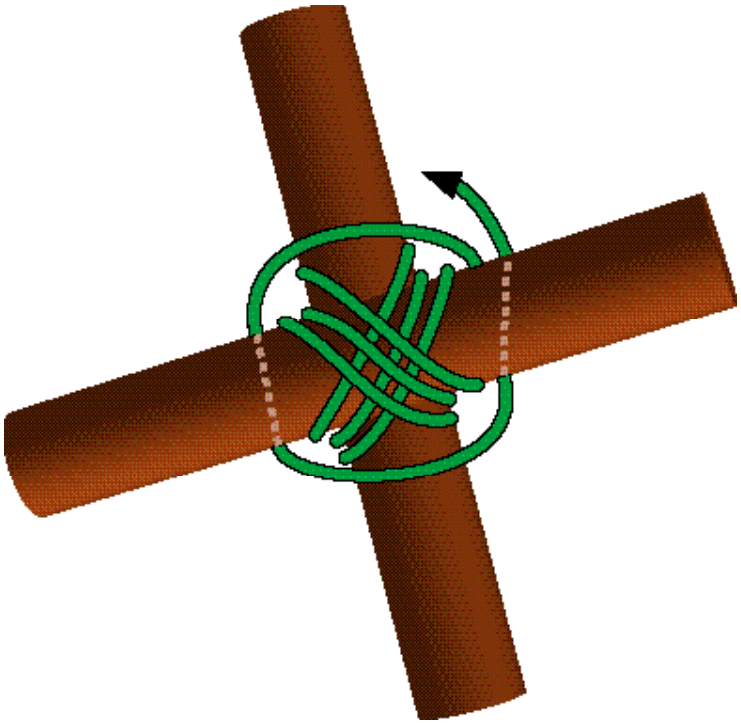


Diagonal lashing is used only when the two crossing spars do not touch one another. The lashing pulls them together and holds them tight.

Begin with two crossed spars and tie a timber hitch across the joint.

Pull the long end of the rope against the loop and continue for three wraps.



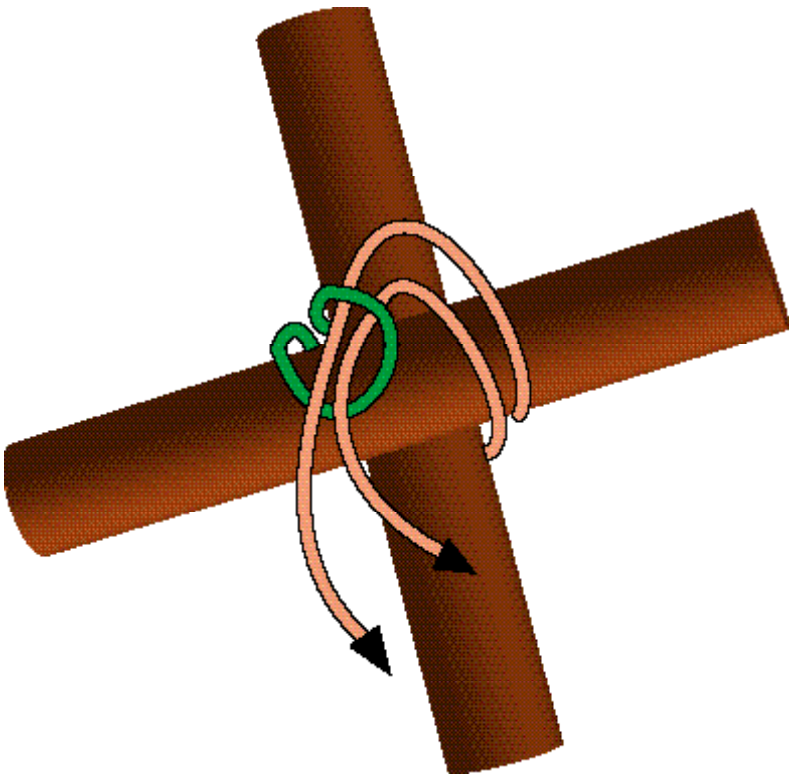


Make three more wraps in the other direction and then two fraps, just as you would in a classical square lashing. Finish with a clove hitch around either spar.

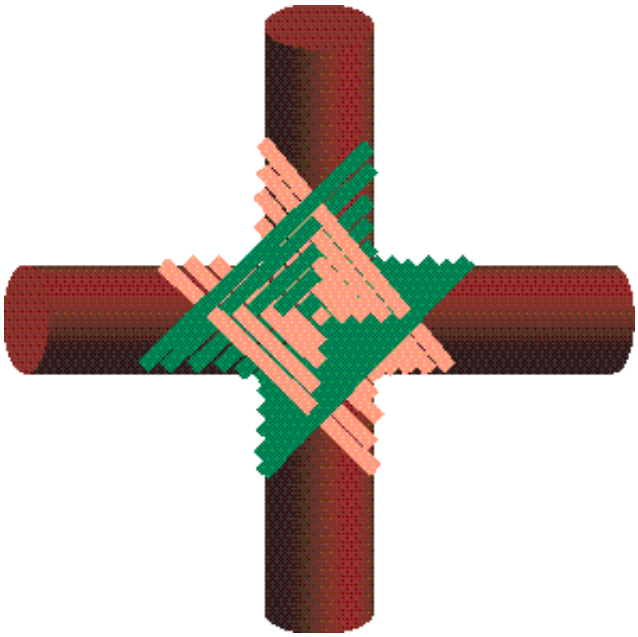
Philippino Diagonal Lashing

Like the Japanese square lashing, the Philippino diagonal lashing is easier to tie, but you need the right length of rope and it is not as strong.

Begin by folding the rope in half. Bring the loose ends around both the spars and through the loop (in a larks head knot). Pull both ends against the loop to bring the spars together and wrap once around the spars; then reverse direction and wrap the other way. Frap once around, split the ropes and tie them around one of the spars using a square knot.



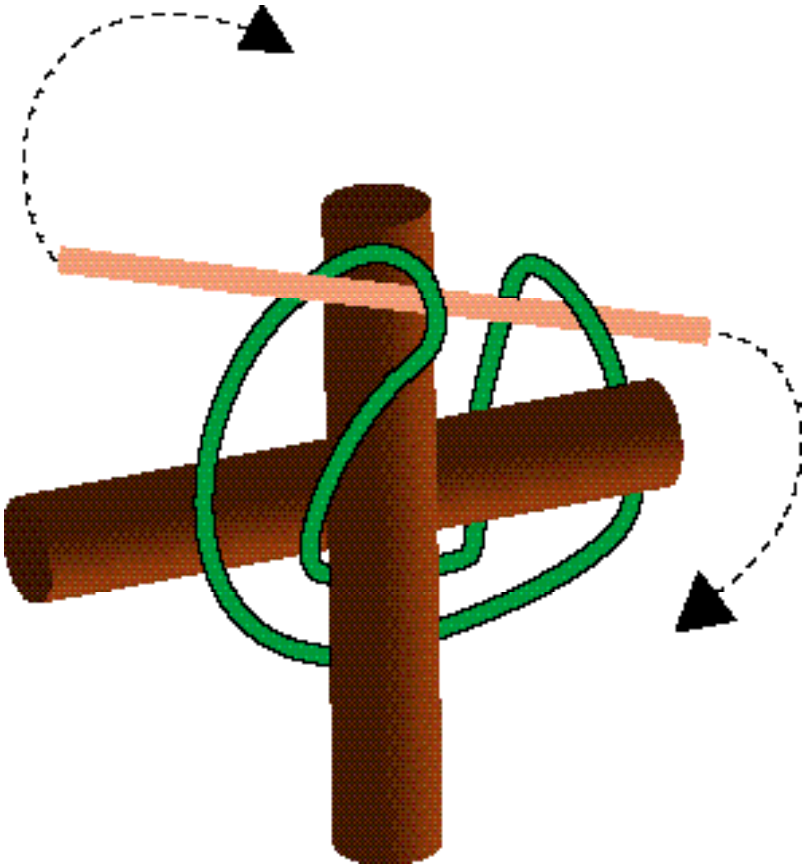
Southsea Island Lashing



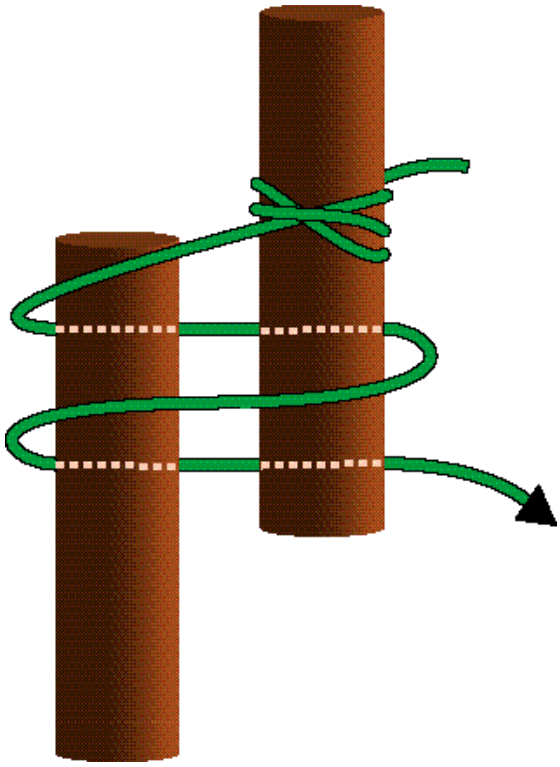
This lashing uses no fraps. Begin with a clove hitch around either spar. Instead of making three wraps one way, then three wraps the other way, alternate your wraps around the joint. Finish off with another clove hitch.

Tourniquet Lashing

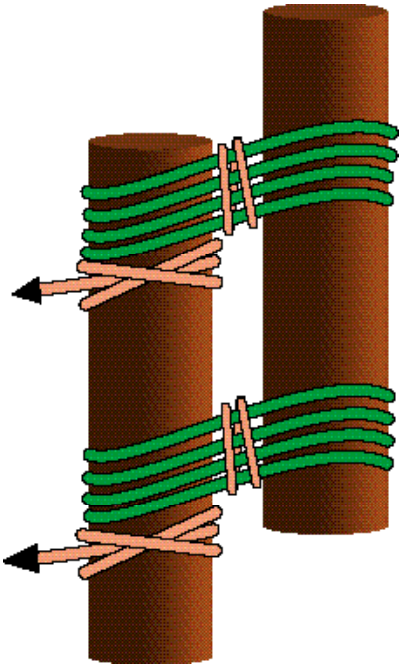
Another quick way of lashing two spars together is the tourniquet lashing. Make a circle out of your line by tying the ends together with a square knot. Then place it around the spars where they cross, as shown below. Put a short spar through the ends of the loop and twist until the lashing is tight. Tie the ends of the small spar to one of the larger spars to hold it in place. This lashing is quick and easy to tie, but it will not be very strong.



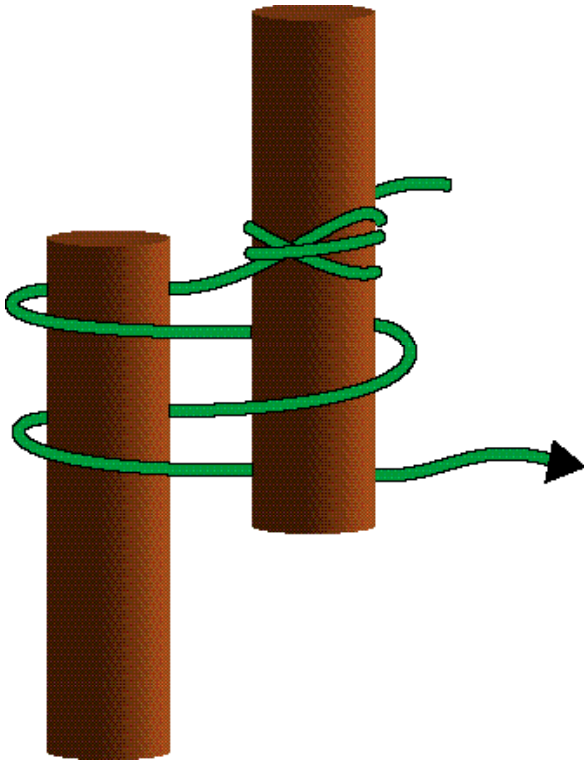
Sheer and Round Lashing



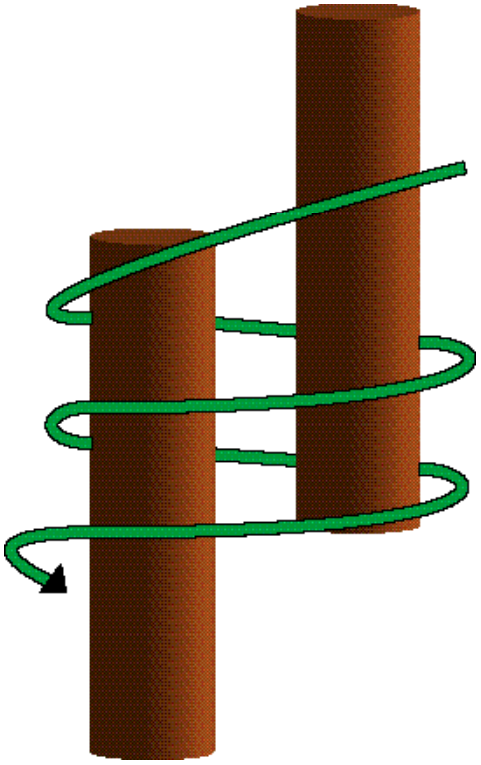
Sheer and round lashings are used to hold two or more "side-by-side" spars together. For sheer lashing, begin with a clove hitch around one of the spars. Wrap the rope around both spars five or six times.



Then frap twice between the spars and finish with a clove hitch on the other spar. Do the same thing further down the spars.

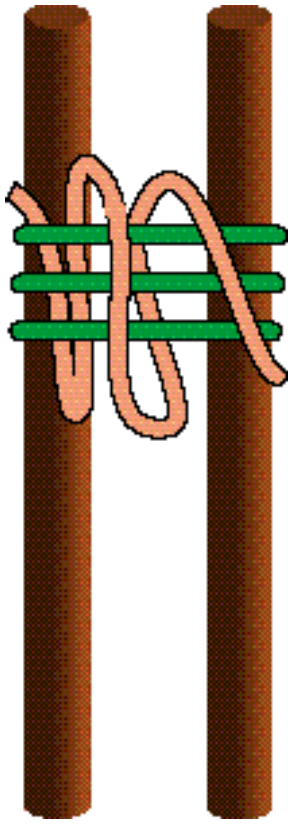


There is another way to make the sheer lashing. Instead of wrapping the rope around both spars, use a "figure 8" pattern, then frap and tie off as before.

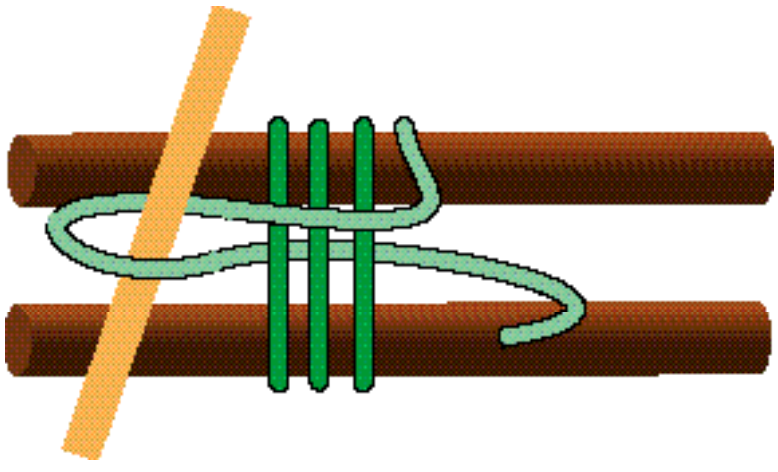


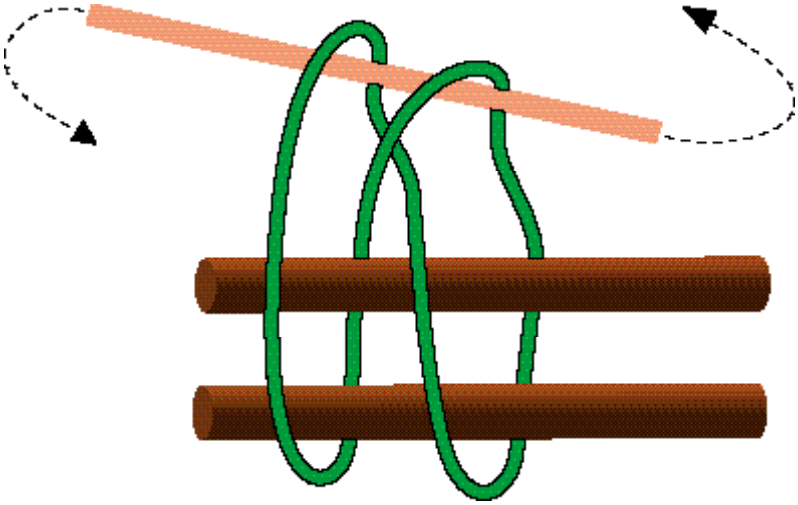
This is a round lashing. It is like the sheer lashing, except that the clove hitches are tied around both spars at once and there is no frapping. Make 5 or 6 wraps and tie the lashing off with a clove hitch, again, around both spars.

This is a quick lash. There are no knots. Instead the ends of the line are tucked under the wraps. As its name suggests, it is very quick to tie, but it is not strong at all. Use it only to make small, temporary structures that will bear no weight.

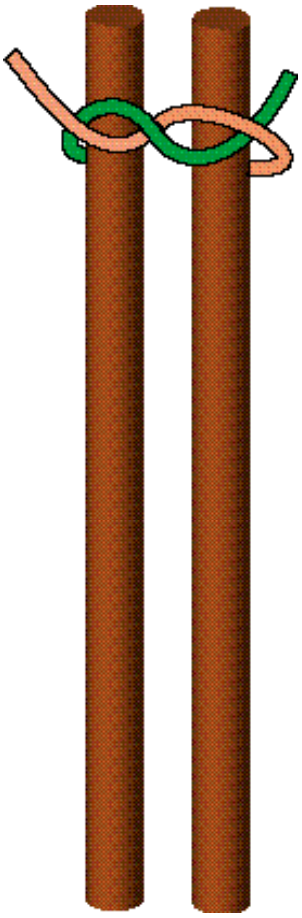


This is a garrote lashing. Begin with a clove hitch, but instead of ending with a clove hitch or frapping as in the sheer lashing, loop the end under the wraps, and put a small spar in the loop. Twist the small spar until the lashing is tight, then tie it down to one of the spars.



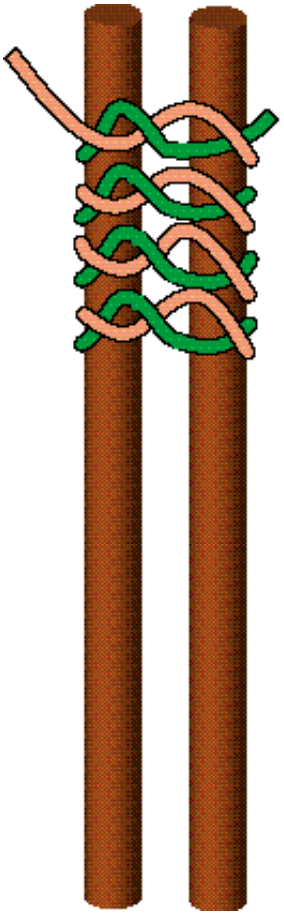


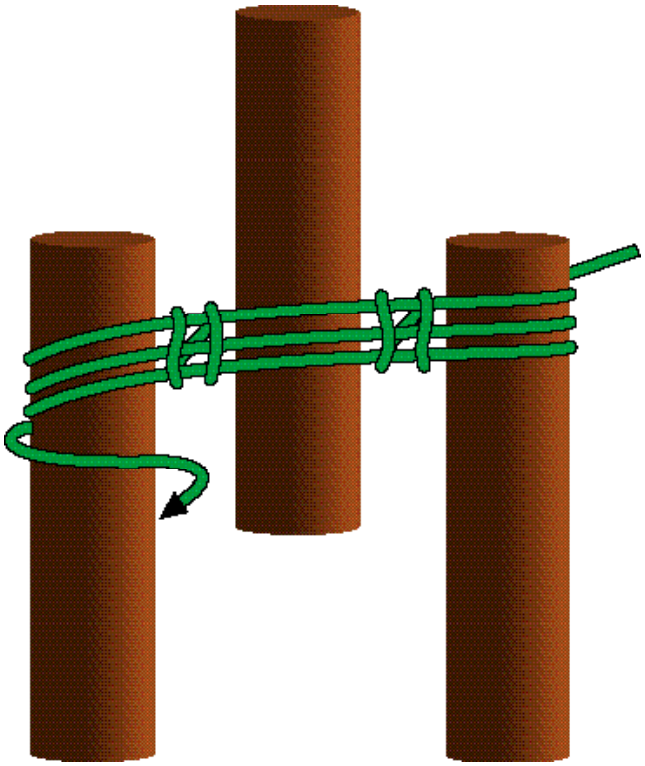
This is another tourniquet lashing, around side-by-side spars instead of crossing spars. The basic idea is the same, though. Make a circle, wrap it around the spars and then use a small spar through the loops to twist and tighten the lashing. Finish it by tying the little spar to one of the large spars.



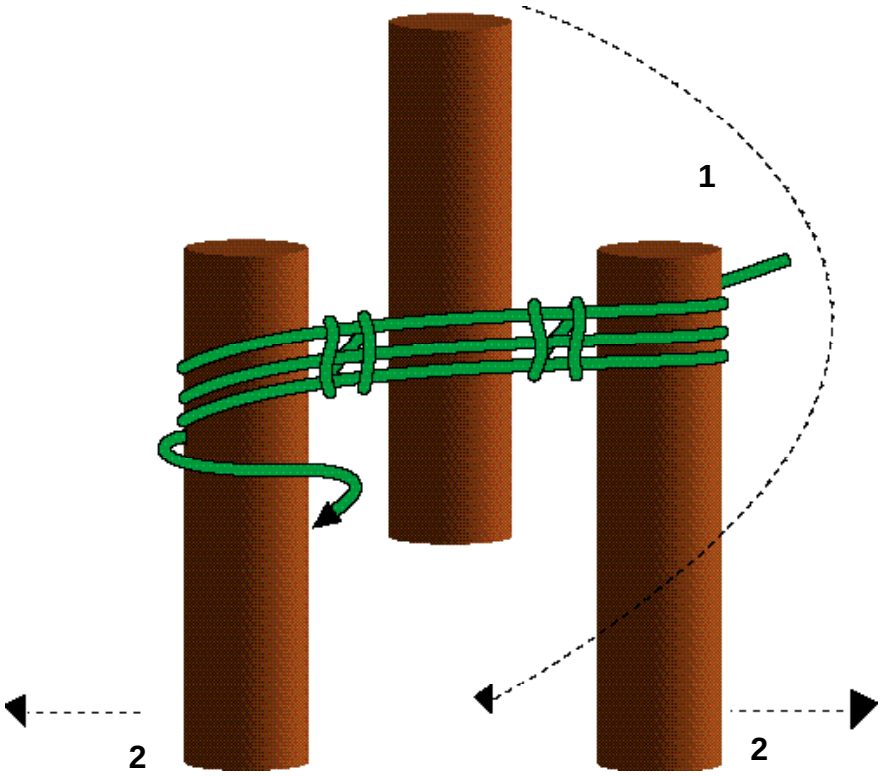
The west lashing is just a lot of overhand knots tied around two spars. Fold the line in half and tie the first knot in the middle. Turn the spars over and tie your second overhand knot.

Turn them over once more and tie another. Keep doing this until all the line is used up or you have enough knots to make the lashing strong.

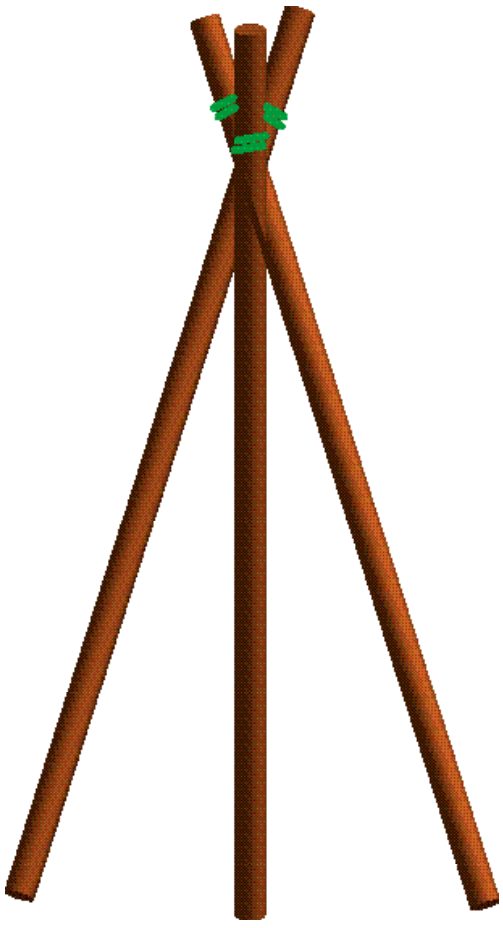




This is a sheer lashing tied around three spars. You can use the regular or "figure 8" methods, but wrap only three times and do not tighten your wraps! Even after you frap between the three spars, the lashing should be a little loose.



If you rotate the top spar down and then spread the two bottom spars to the sides, you will have made a tripod.



These are the basic lashings. Most of the things you make will use them. There are some other projects that will use other knots and lashings, but we will talk about them later.

For now, why don't you start by making the tripod, and then we'll go on to learn about more things you can build.

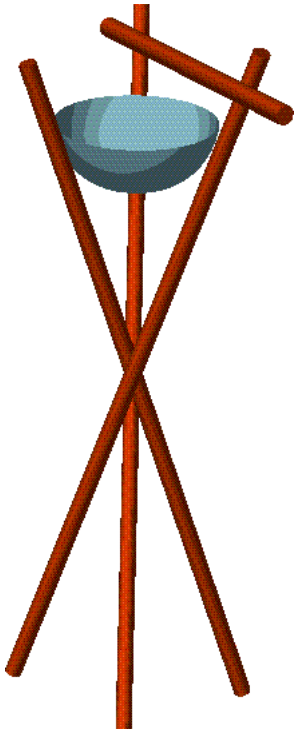
Note:
In the following chapters, the pictures will not always show the rope ties used in lashing. This will make it easier to see how the projects are put together. Whenever two spars cross, there should be a lashing, and usually it will be a square lashing.

CHAPTER III
CAMP GADGETS

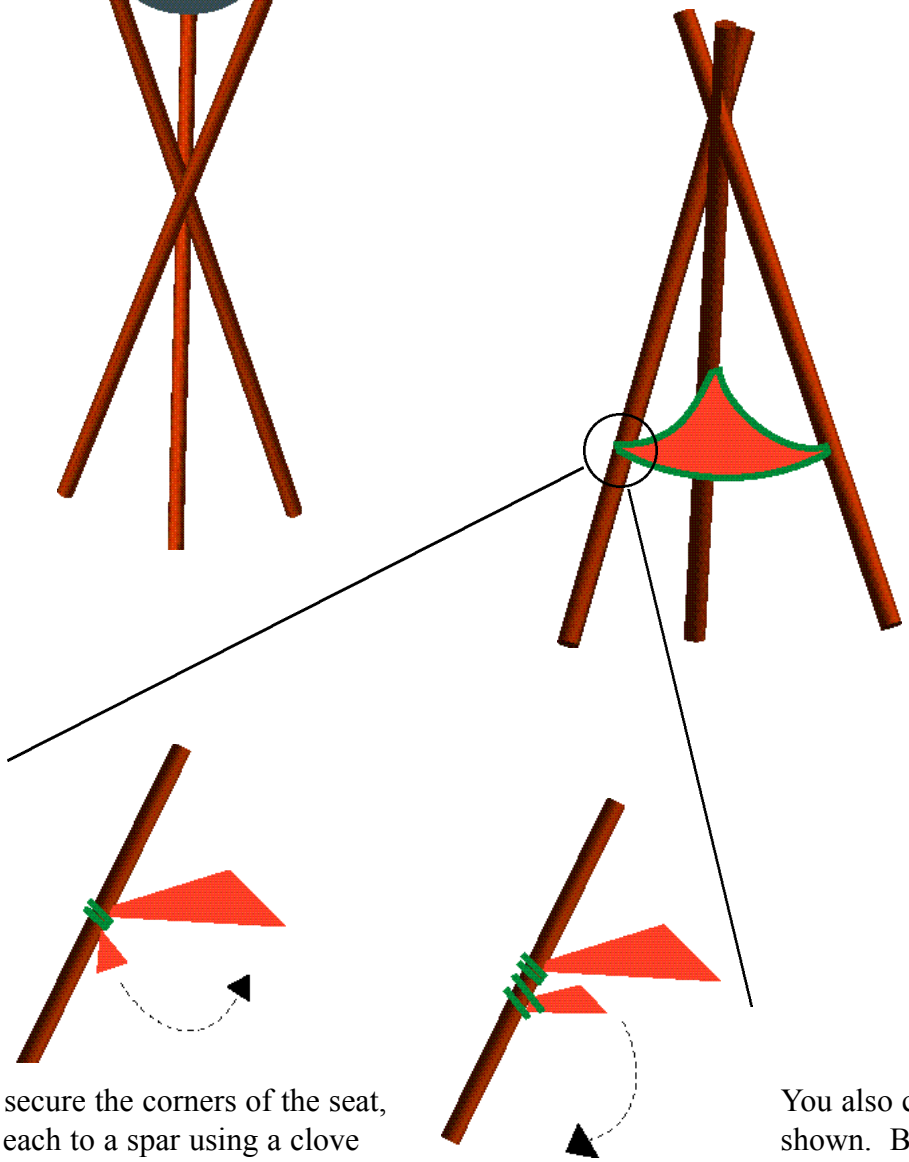
Wash Stand and Camp Seat

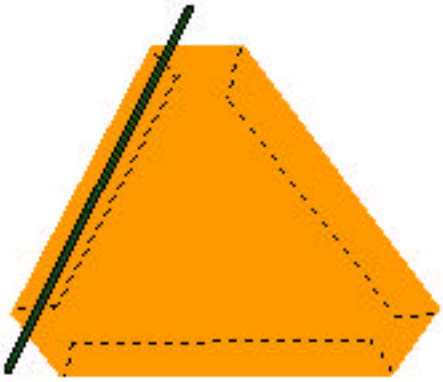
Do you go camping? There are lots of things you can make for your campsite out of rope and spars. You can start with a simple wash stand and go on to make tables, seats and many other useful projects.

Here's a simple wash stand. It is based on a tripod lashed in the middle rather than the top. You wedge your wash basin on top. If two of your spars are longer than the third, you can lash a cross bar and use it as a towel rack.



Using another tripod, you can make a simple camp chair. You will need a very strong piece of canvas or leather for the seat. Either lash the ends of the seat directly to the tripod as shown below, or sew the lashing ropes into the seat.

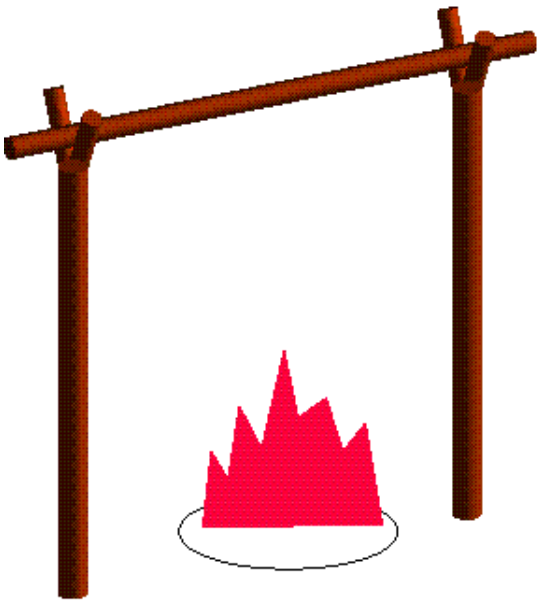


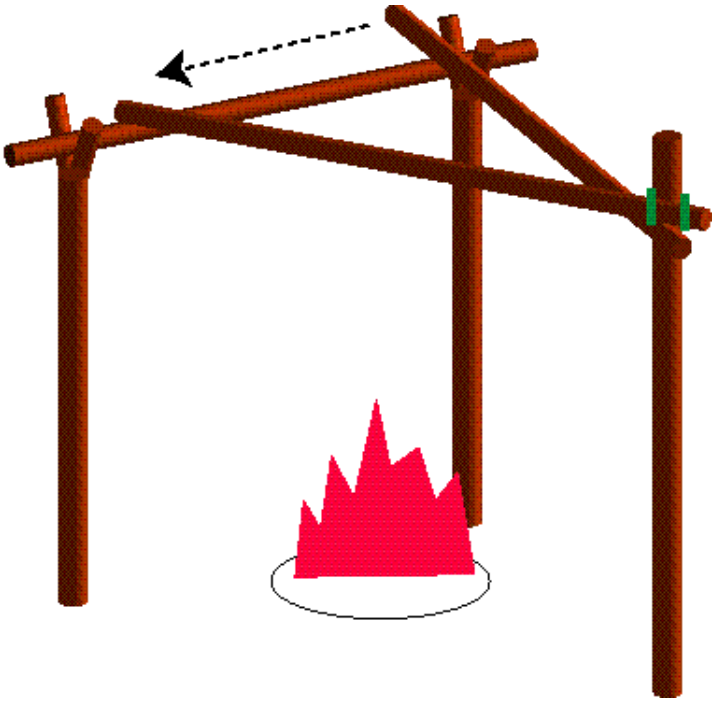


To secure the corners of the seat, tie each to a spar using a clove hitch, a double turn and another clove hitch. Then raise the corner flap and lash it again to the spar using a double turn and another clove hitch.

You also can sew the ropes into the seat, as shown. Be careful that the stitching is strong enough to hold your weight, then tie the ropes to the spars using a clove hitch followed by two half hitches.

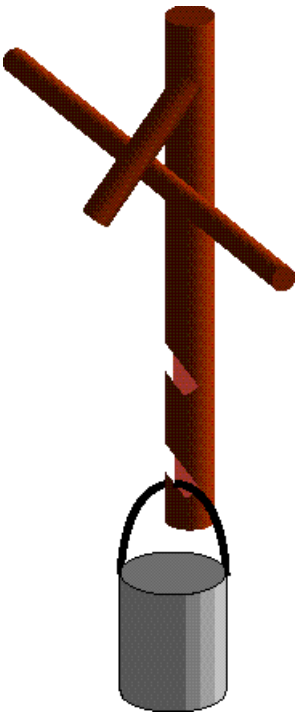
Spits





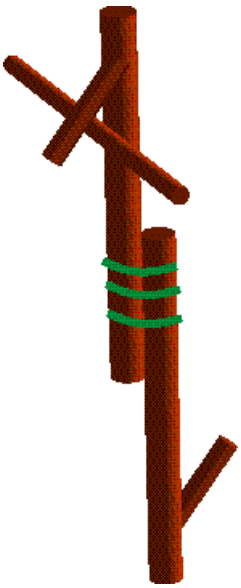
Spits are used to hang pots over outdoor cooking fires. On the left is a simple spit. It is made by driving two forked sticks into the ground and laying a spar across them. Be sure that the forked sticks are long enough so that the cross-spar is not too close to the fire. The picture on the lower left shows a "pot-hook" you can make to hang your cooking pots at different levels over the fire.

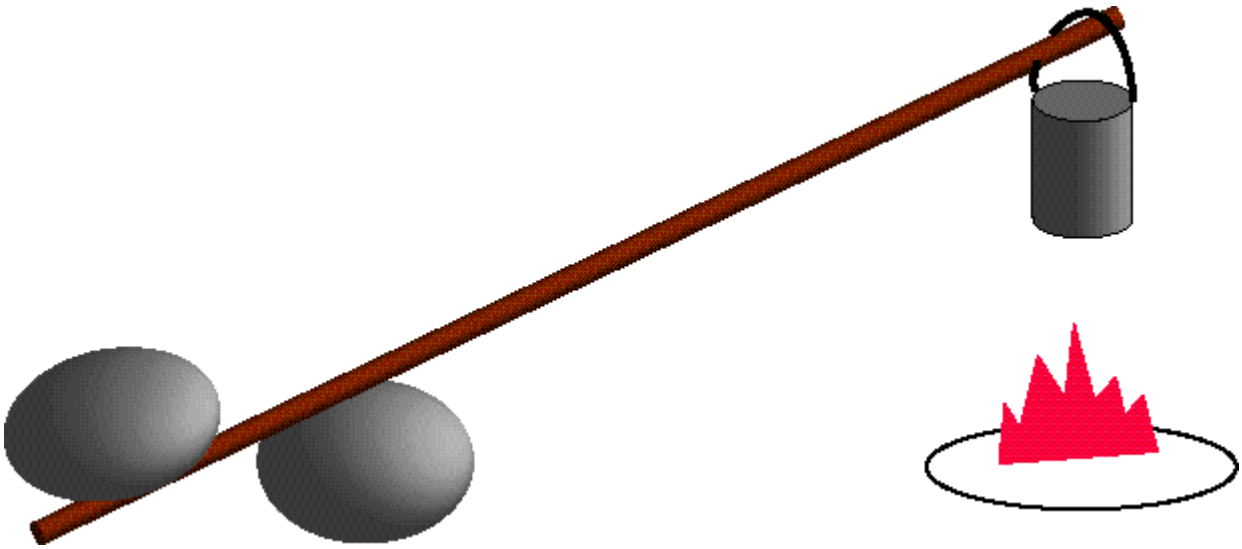
On the upper right is a movable spit using three upright spars. The extra cross-spar is lashed to the third upright, but not to the other cross-spar. That way you can slide it over and away from the fire. Hang your cooking pot from this spar. You will be able to move the spar away from the heat before touching the pot.



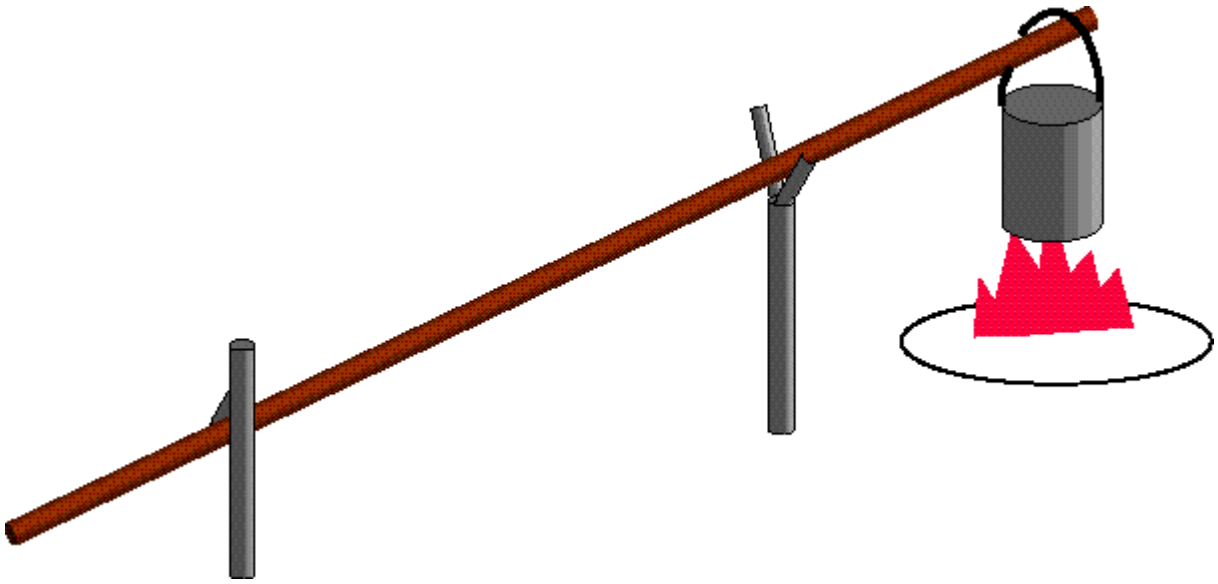
You make the pot-hook by using a forked stick spar with one branch cut off a few inches from the joint. Then use a saw to cut two deep notches in the spar at an angle opposite that of the branch. Hook the branch over the cross spar and the cooking pot on either notch.

If you can't saw notches, you can lash two forked sticks together as shown on the right. But be careful that the fire does not burn the rope.





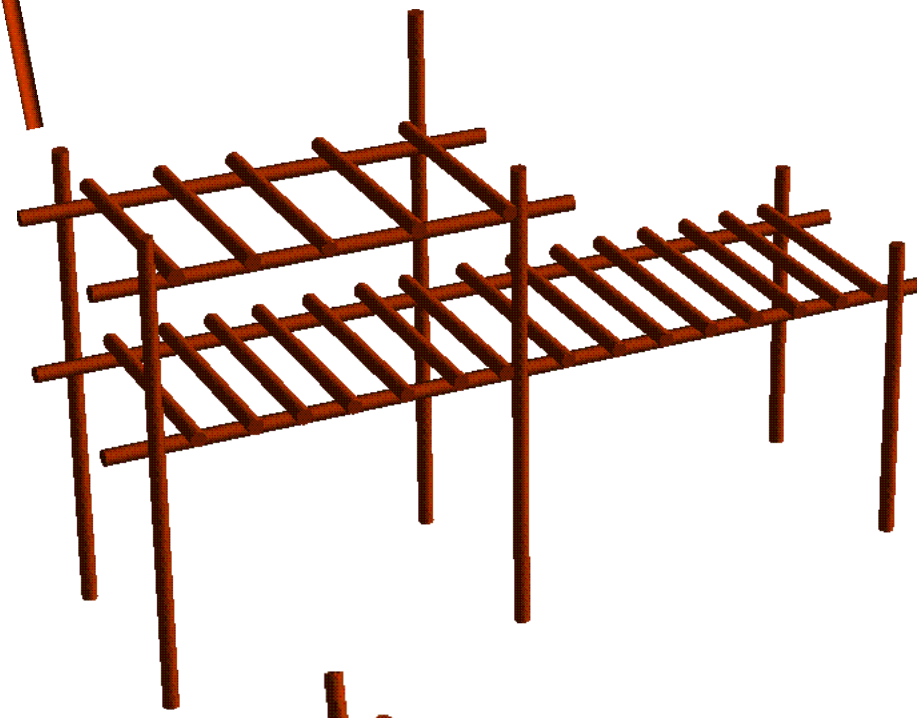
Here are another two spits that make use of the “lever” principle. Each requires a long spar. In the first, the spar rests on a large rock or log with another rock or heavy log holding down the end. If you do not have any large rocks, you can cut two more spars. The first has a fork on the end; the second, a short branch. Be sure that both spars are driven deep into the ground. Remember that the weight of your cooking pot will pull against either the upper rock (in the first example) or the rear spar (in the second example).

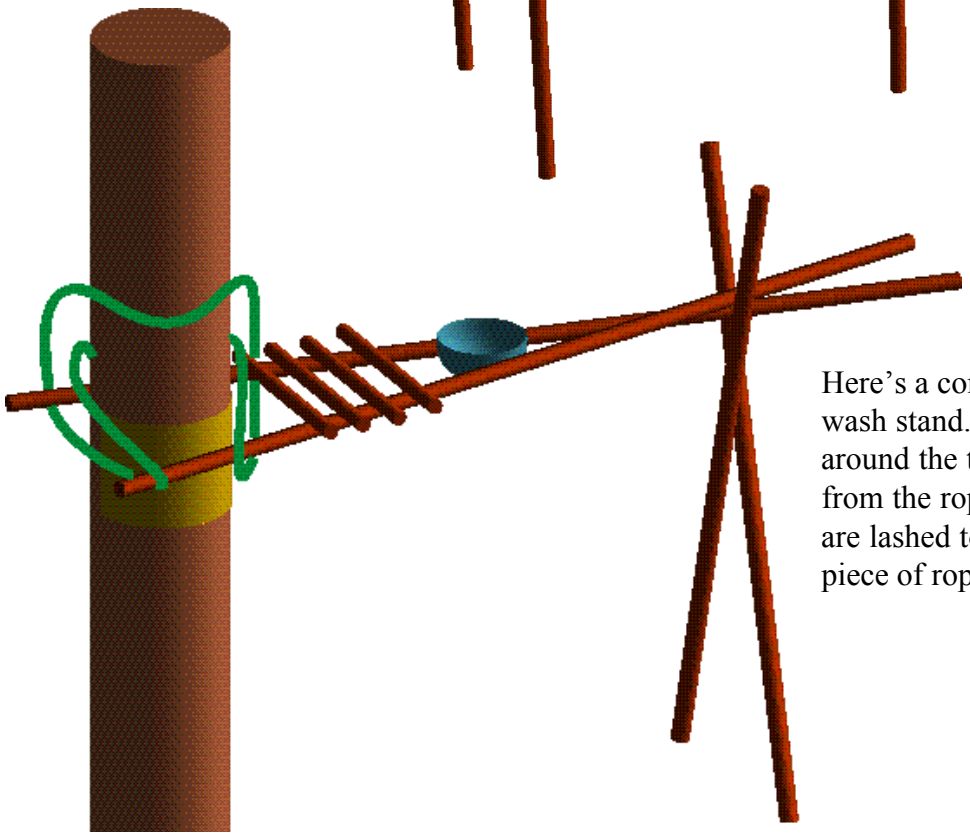


Tables

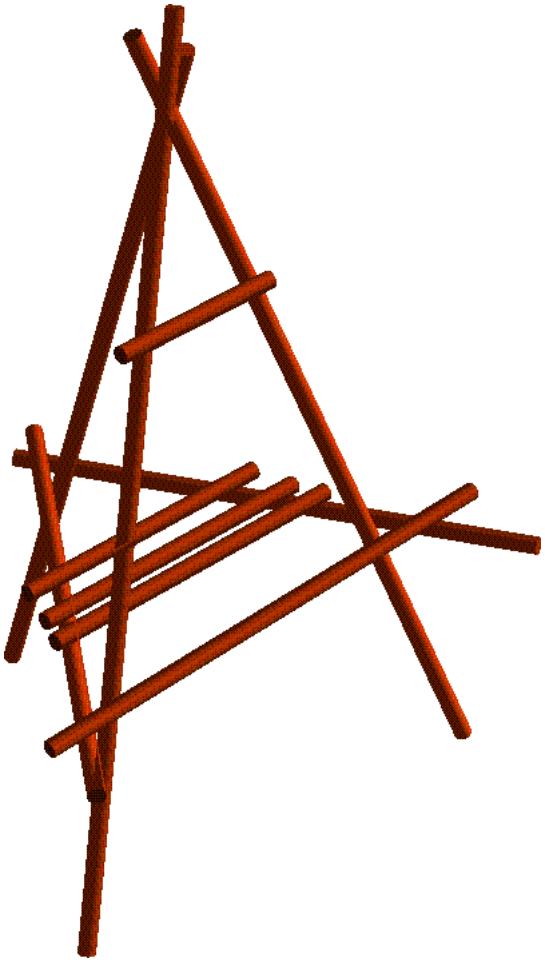
Like spits, there are many different kinds of tables, both simple and fancy. Here are two simple tables. The first has crossed legs. The second has straight legs. In both cases you must drive the legs into the ground to make them stable. Otherwise, you can attach cross-spars (not shown) that will make them rigid.

Note that the second table has an upper "shelf." You can use either as a "kitchen" or utility table.



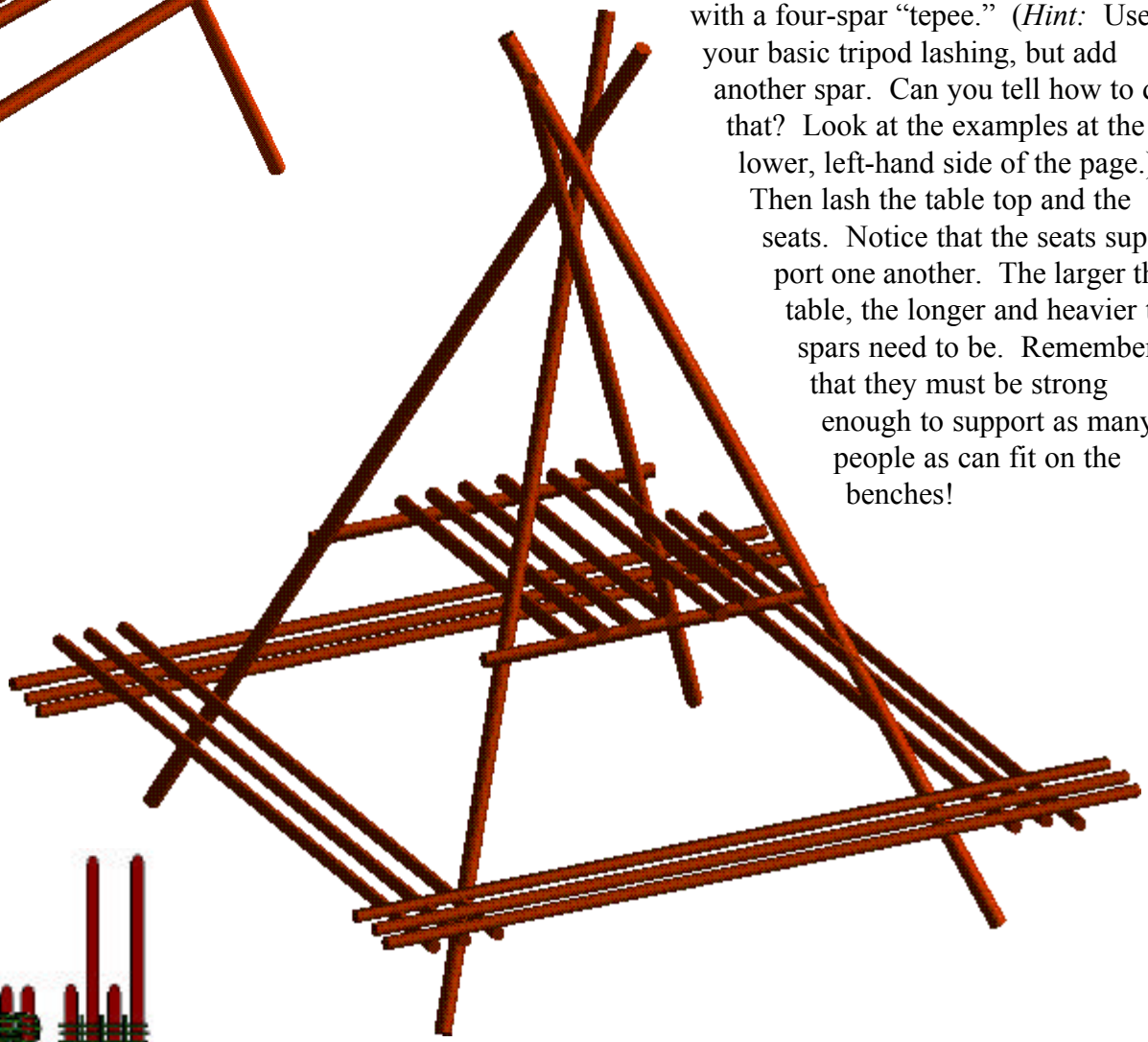


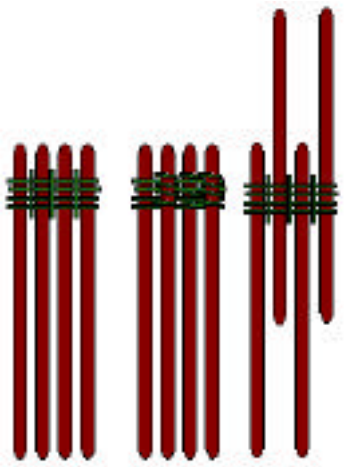
Here's a combination table and wash stand. There is padding around the tree to protect the bark from the ropes and spars. The spars are lashed to the tree using a single piece of rope.



Here's another kitchen table. This one is based on a tripod.

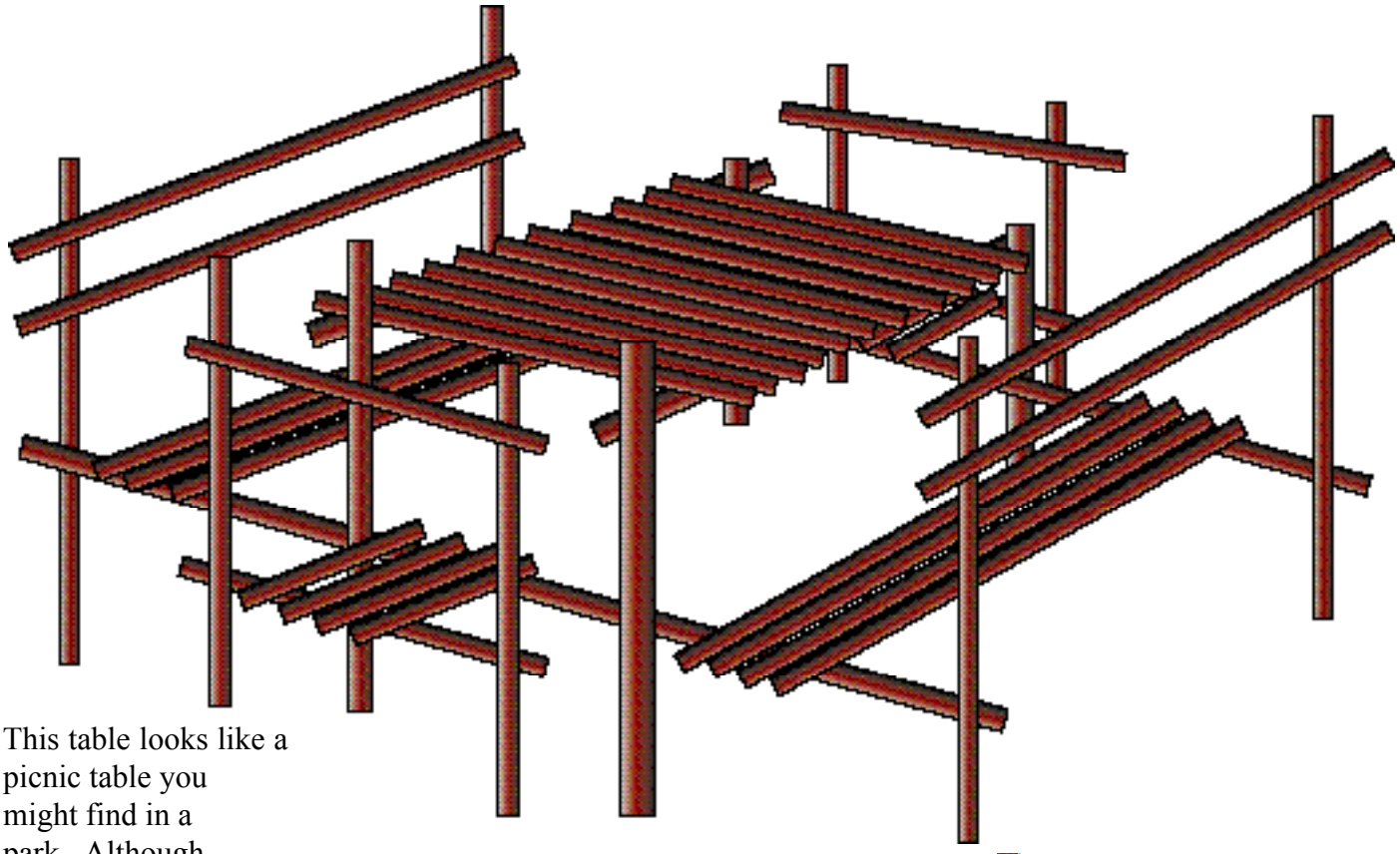
This is a Chippewa Table. It has both a table top and four bench seats. Begin with a four-spar "tepee." (*Hint:* Use your basic tripod lashing, but add another spar. Can you tell how to do that? Look at the examples at the lower, left-hand side of the page.) Then lash the table top and the seats. Notice that the seats support one another. The larger the table, the longer and heavier the spars need to be. Remember that they must be strong enough to support as many people as can fit on the benches!





Use any of these three ways to lash the top together. They are like the tripod lashing with an extra spar.

Two Picnic Tables

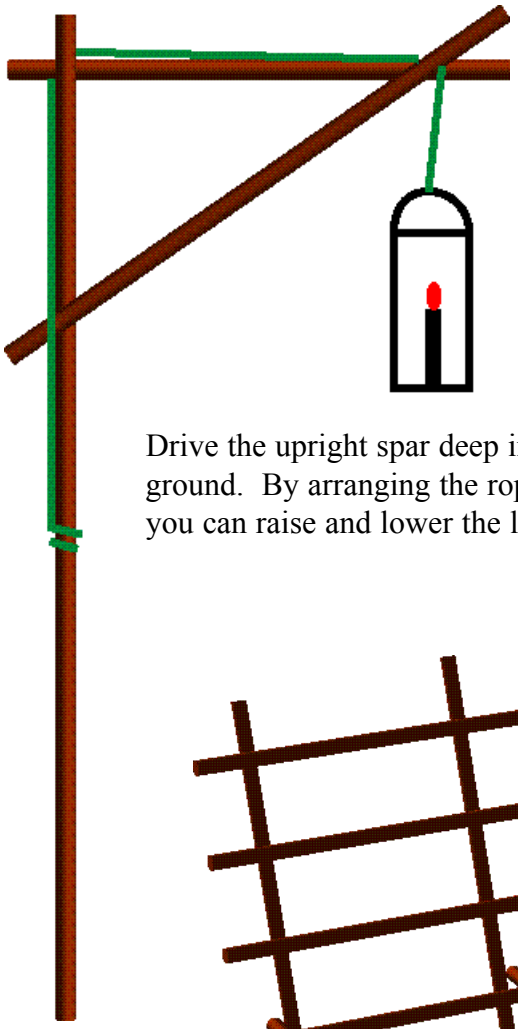


This table looks like a picnic table you might find in a park. Although you need a lot of spars, it is really simple to make.

Here is a table made from two tripods. See Chapter IV to find out how to make the top of the table.

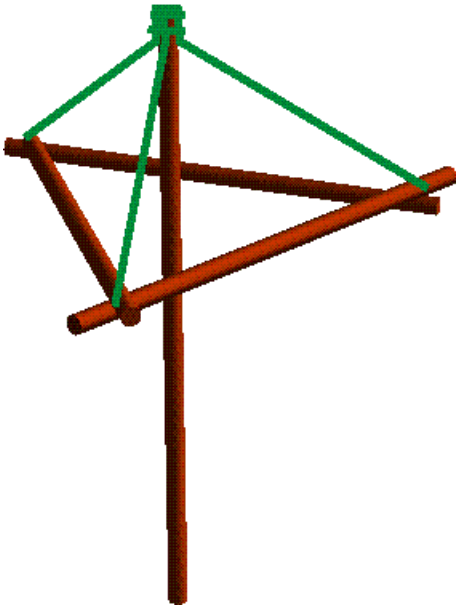
Odds and Ends

Lamp Post

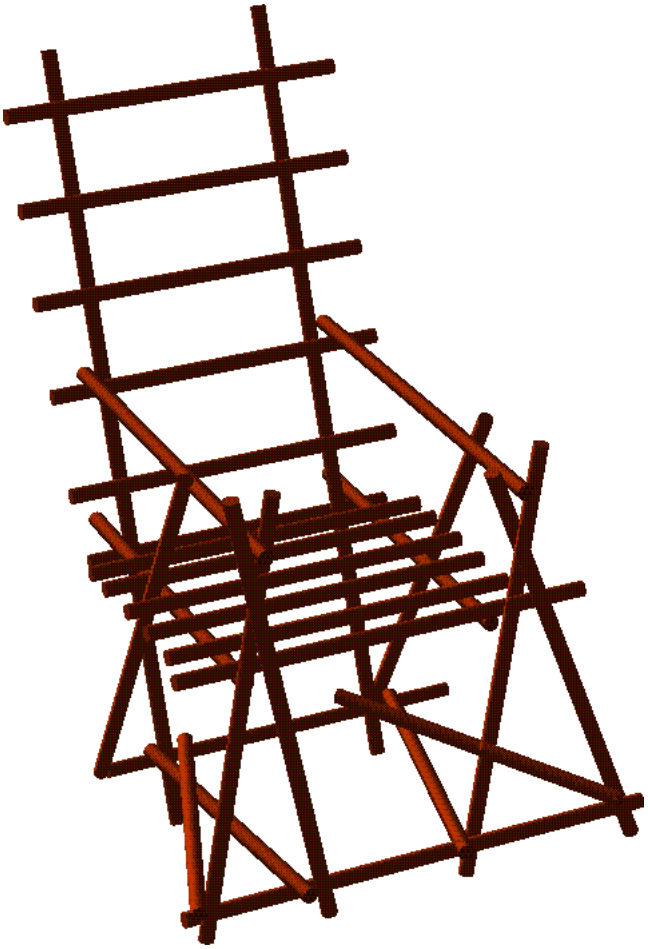


Drive the upright spar deep into the ground. By arranging the rope as shown, you can raise and lower the lantern.

Sock Dryer

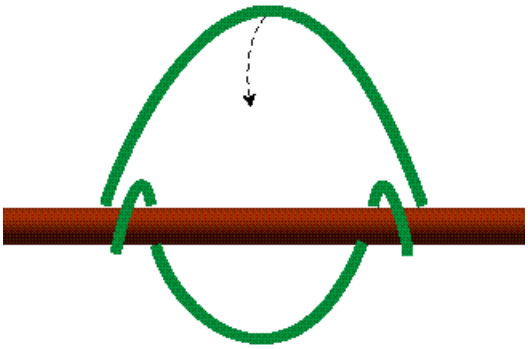


This strange device is a sock dryer. Drive the upright spar into the ground. Lash together a simple triangle and attach it to the upright as shown.



Fancy Chair

Here's a fancy chair. It looks hard to make, but it's not. You now know all the knots and lashings necessary to build it. It will take a while to make, but there is nothing difficult about it.

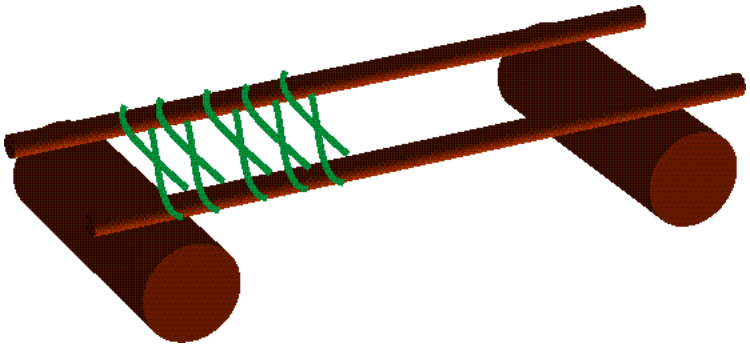


Hanger

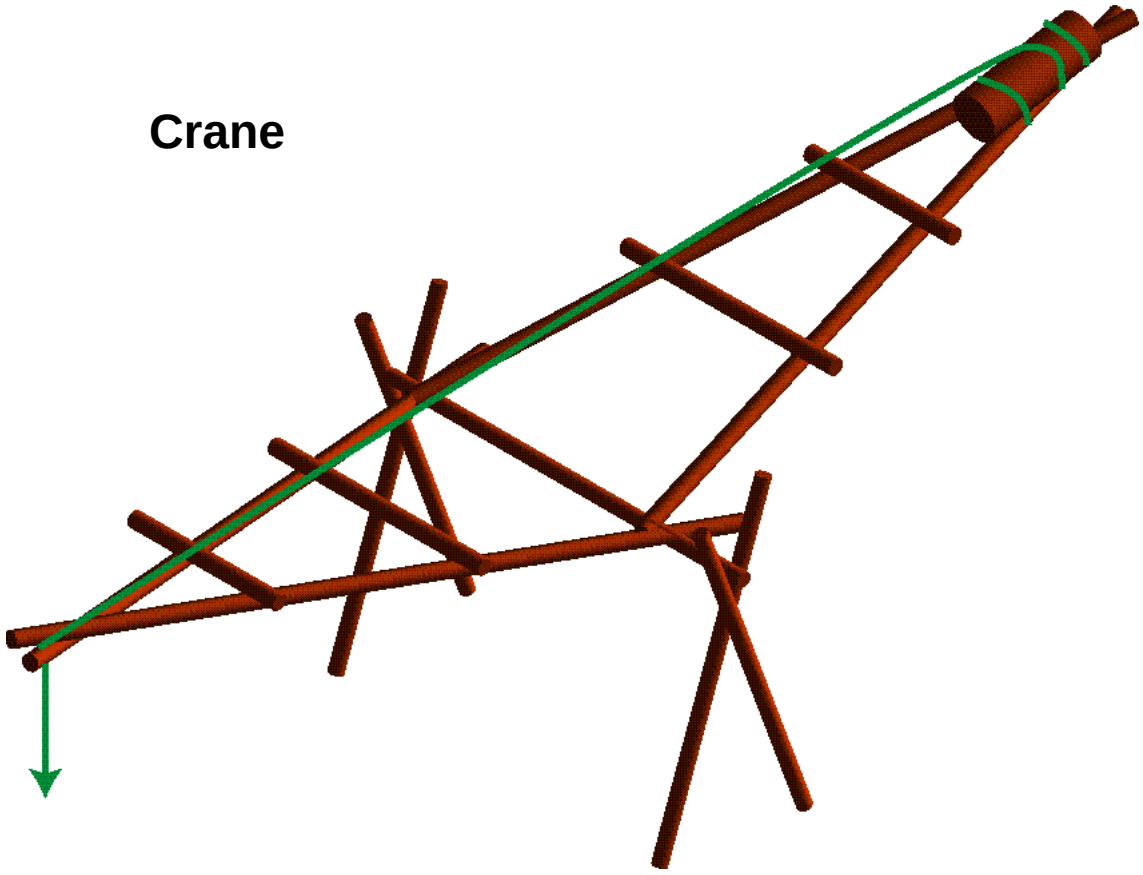
Need to hang something from a branch without tying any knots on the branch itself? Try this hanger. It's a single piece of rope with the ends tied together using a square knot. You loop the rope over a branch as shown to finish it.

Log Bench

Or how about this log seat? You can build it using two long spars laid across a pair of logs. Then lace rope from spar to spar as shown. For extra strength, you can add more spars and weave the rope over and under them.

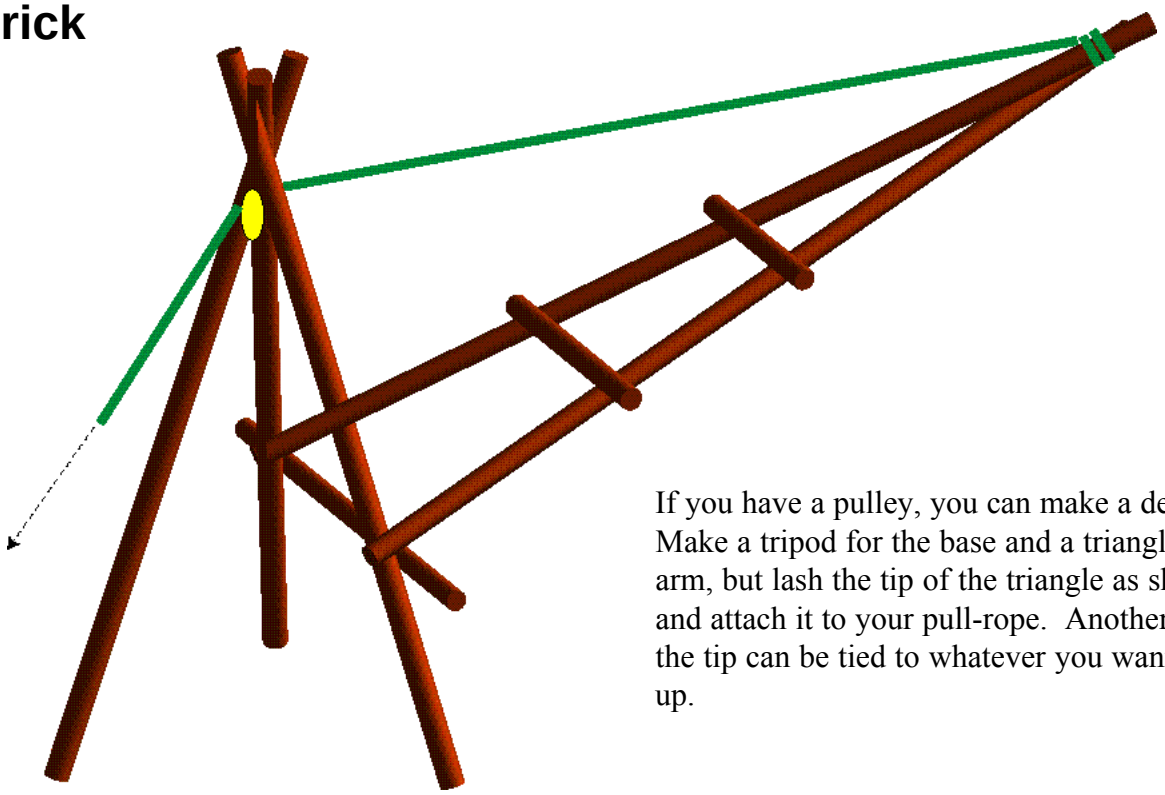


Crane



Here's a "counterweight" crane used for lifting heavy things. The base and the two arms are made from bipods (two spars that cross at one end). A heavy log on one end is the counterweight and a strong rope holds the two arms up.

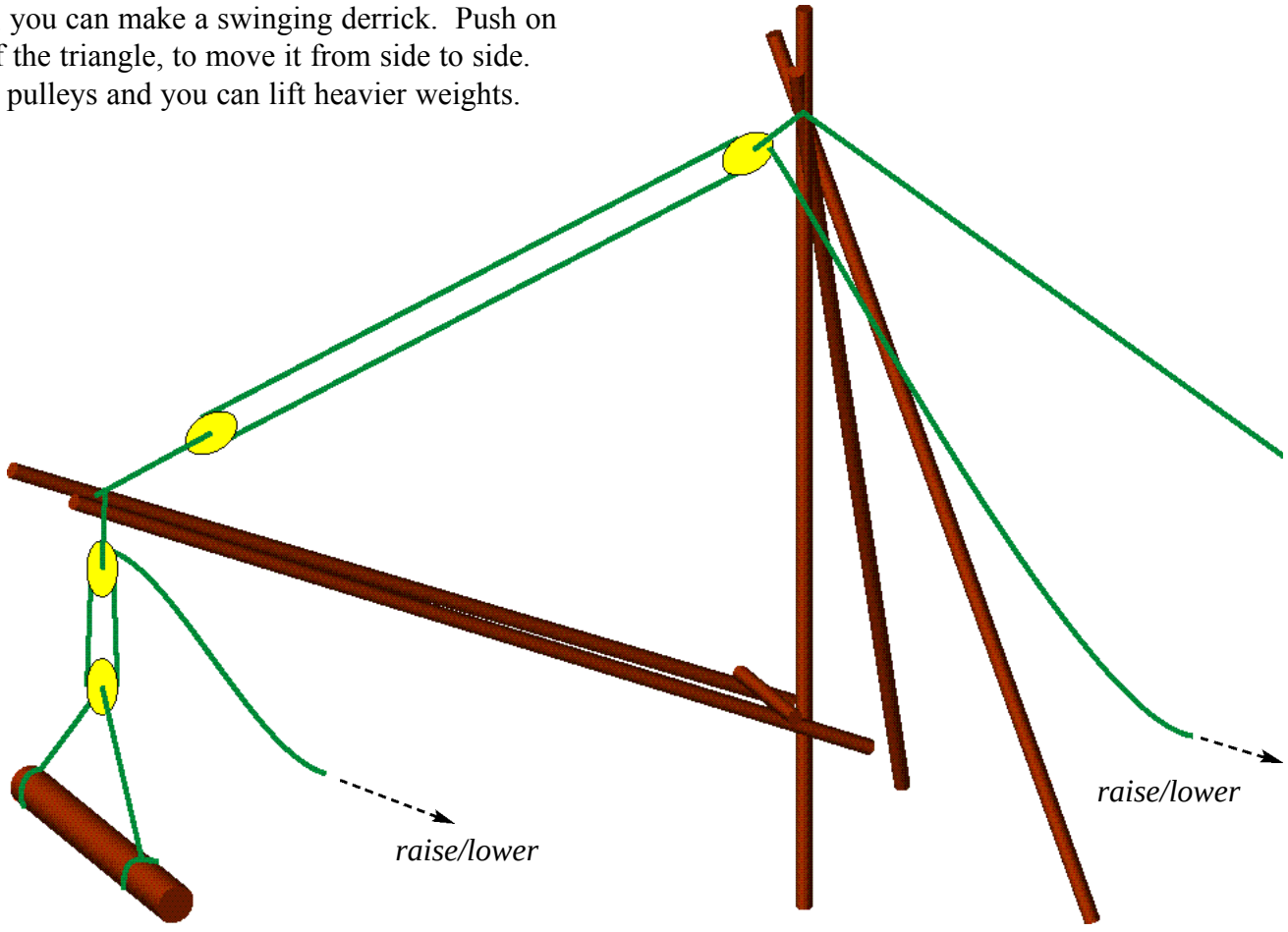
Derrick



If you have a pulley, you can make a derrick. Make a tripod for the base and a triangle for the arm, but lash the tip of the triangle as shown and attach it to your pull-rope. Another rope at the tip can be tied to whatever you want to pick up.

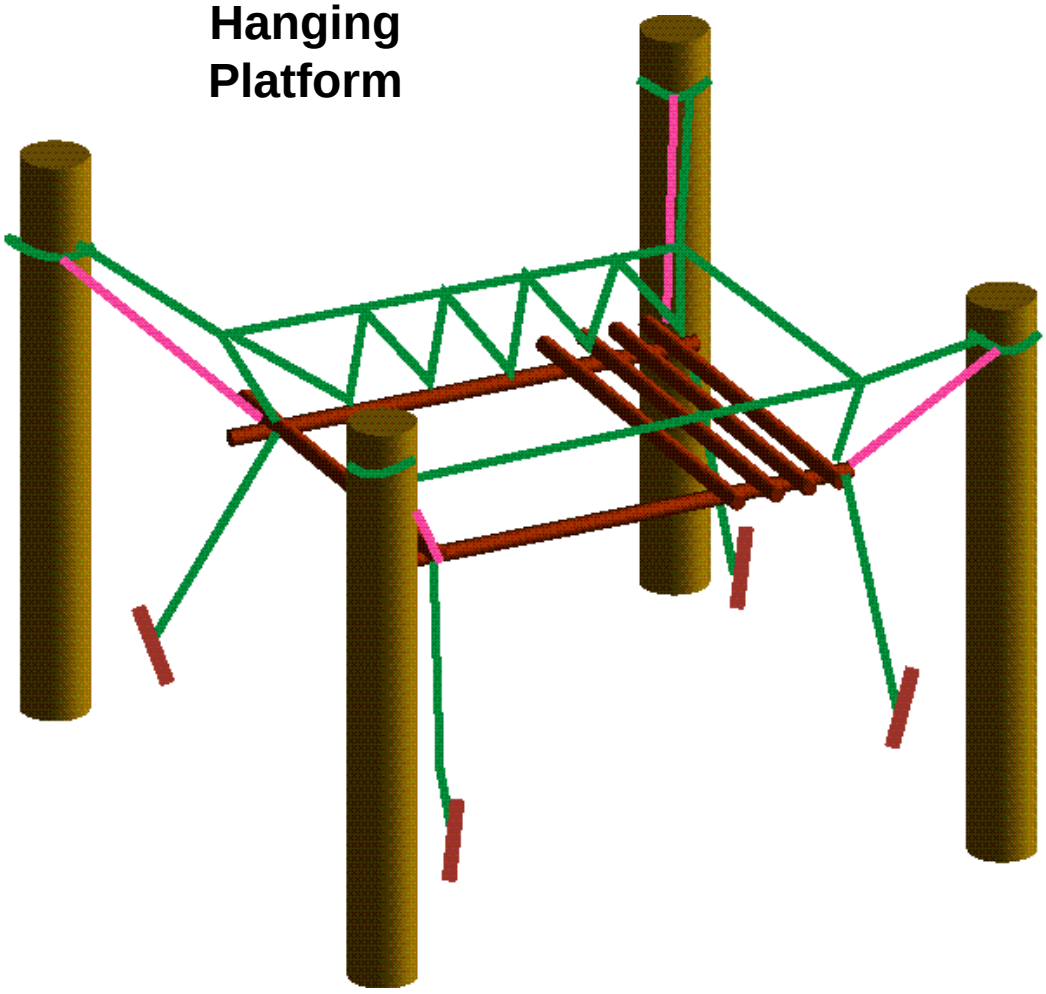
Swinging Derrick

If you turn the tripod around and lash the triangle to a single leg, you can make a swinging derrick. Push on the side of the triangle, to move it from side to side. Add more pulleys and you can lift heavier weights.



Hanging Platform

What if you go camping and there's no dry ground where you can set up your tent? With four strong trees, some spars and rope, you can build a platform off the ground on which to set up your tent.



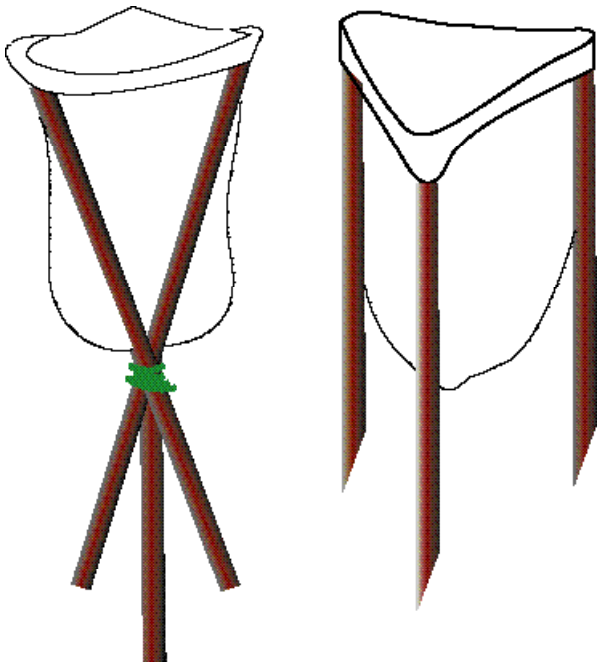
First build a basic platform. Lash four long spars together in a square or rectangle frame (whatever size you need to hold your tent). Then lay cross spars side by side, all the way across the frame. Use very strong rope (shown in pink) to suspend this platform from the trees. With more rope you can make a railing and anchor the platform to the ground so that it will not sway.

If the platform is high enough, make a rope ladder to reach it. (See Chapter IV, on ladders, for more instructions on building the platform and the Brynbach Tower in Chapter IX for making a rope ladder.)

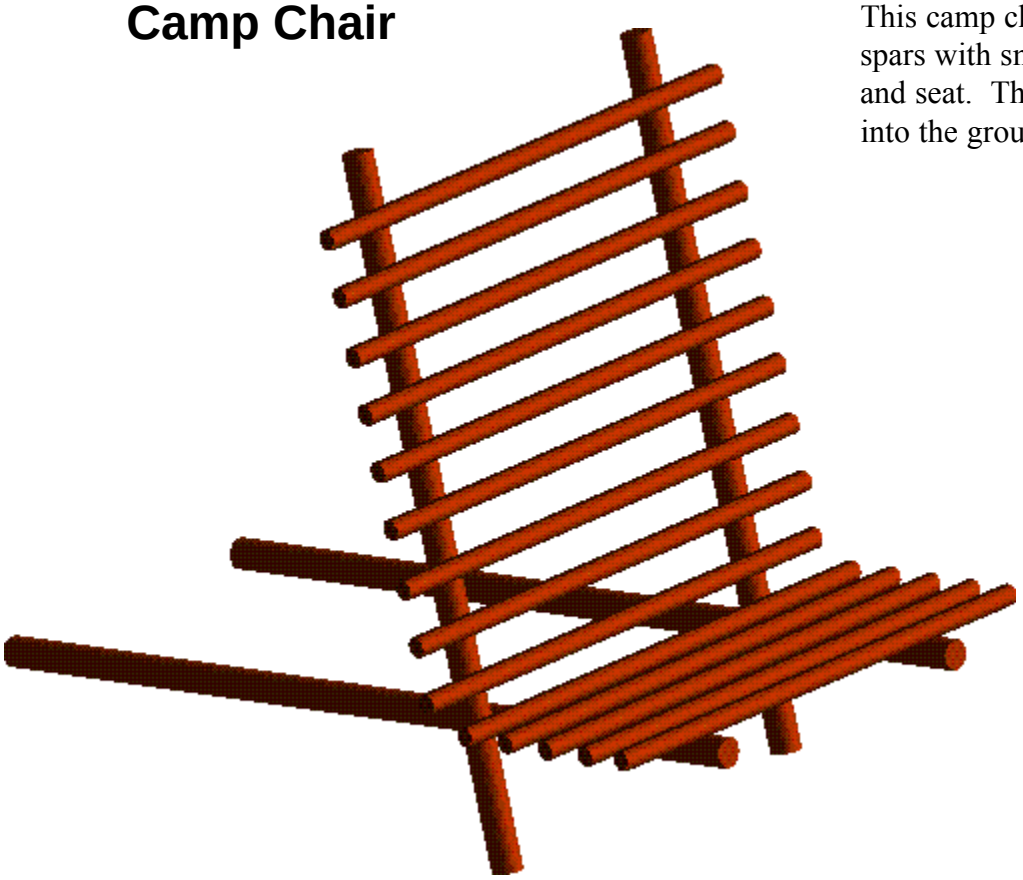
Remember: Put padding where your ropes go around the trees so that they will not be harmed!

Trash Holders

Here are two simple trash holders. One is made by driving three sharpened spars into the ground and hanging a plastic trash bag over the ends. The other uses a simple tripod lashed below the middle of the three spars.

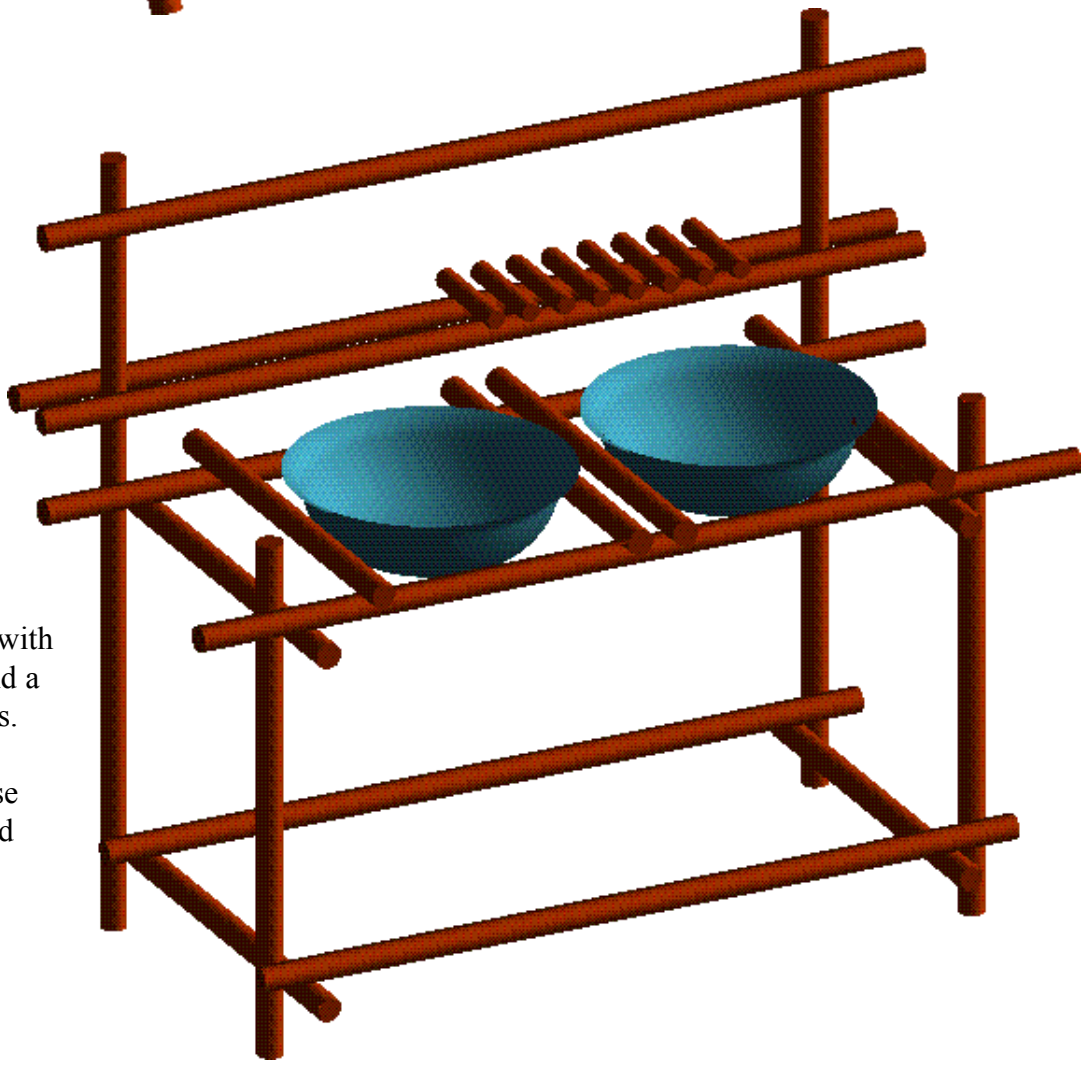


Camp Chair



This camp chair is made with four heavy spars with smaller spars forming the back and seat. The heavy spars should be sunk into the ground.

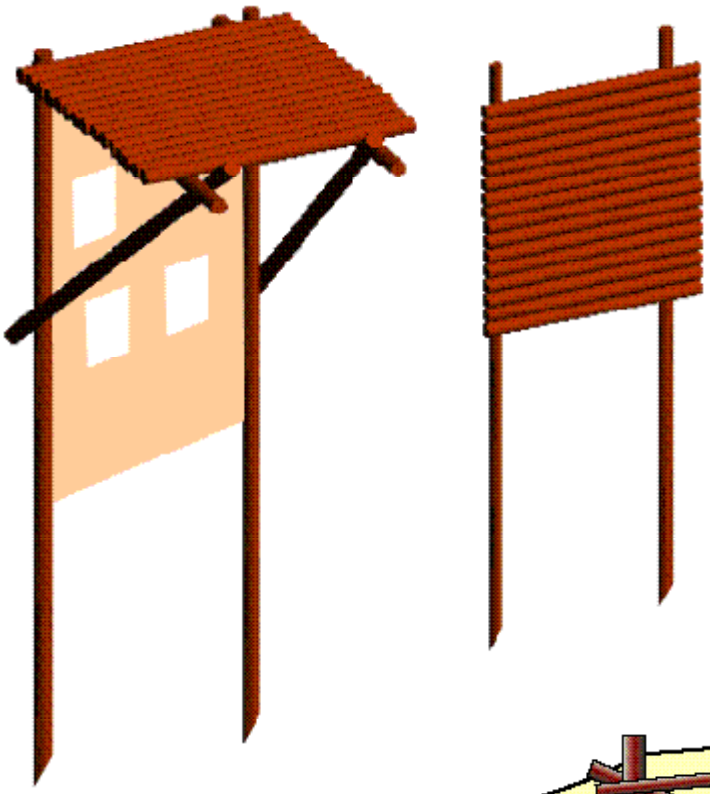
Double Wash Stand



Here's a fancy wash stand with two basins, a towel rack and a shelf for soap and wash kits.

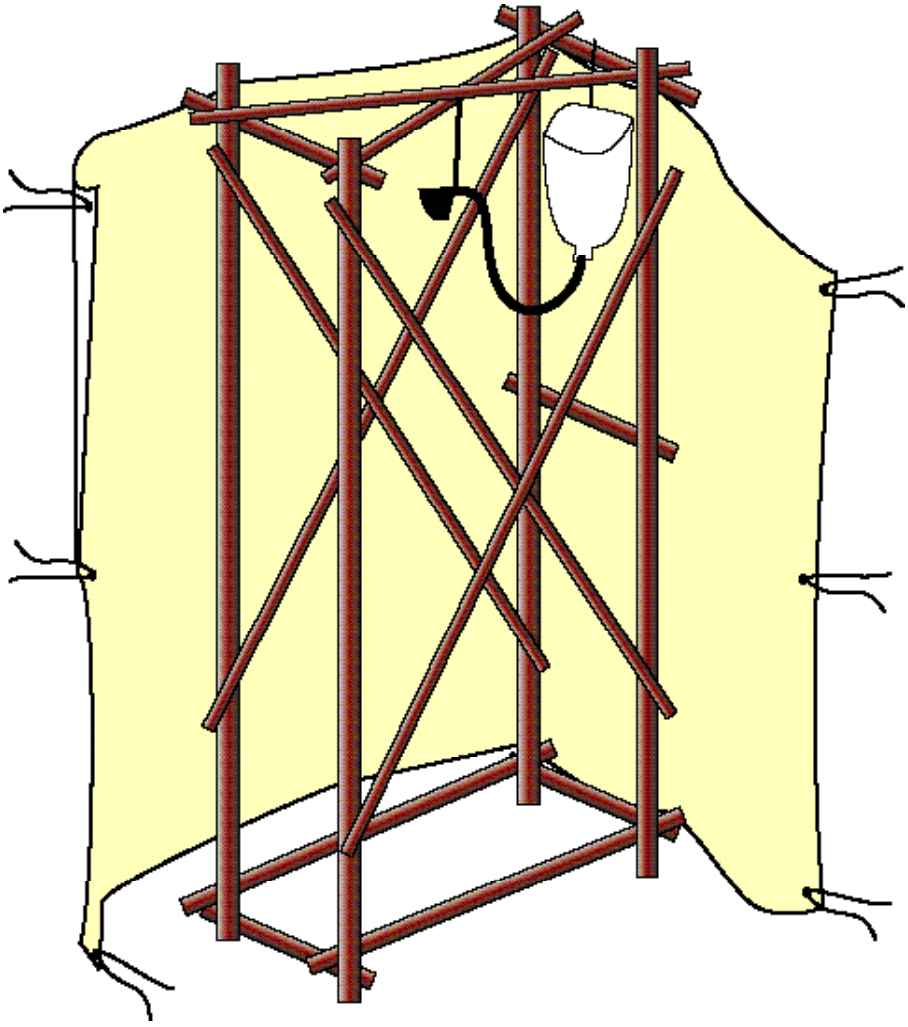
If it needs more support, use cross braces in the front and back and on the sides.

Bulletin Boards



These are two kinds of bulletin boards or signposts you can make. The one on the left uses a pegboard or plywood. The upright spars are driven into the ground. Use your imagination to think of other designs.

Shower

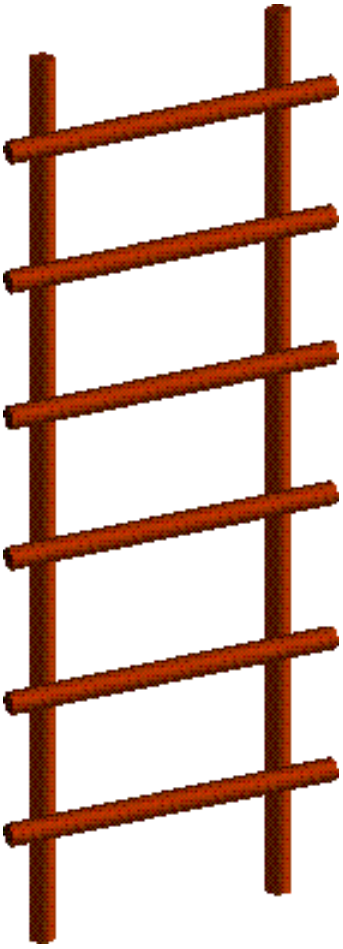


For the shower, hang a one-gallon plastic milk container from one of the top spars. Attach a rubber tube to the opening. At the other end of the tube, put a spray nozzle and hang that from the center. Wrap a tarp around the shower, and tie it securely on three sides. On the fourth side, make the ties so that you can undo them to get into the shower. Believe it or not, the rays of the sun will warm the water to a comfortable temperature, and one gallon is more than enough water for a person to take a shower.

CHAPTER IV
LADDERS & RAMPS

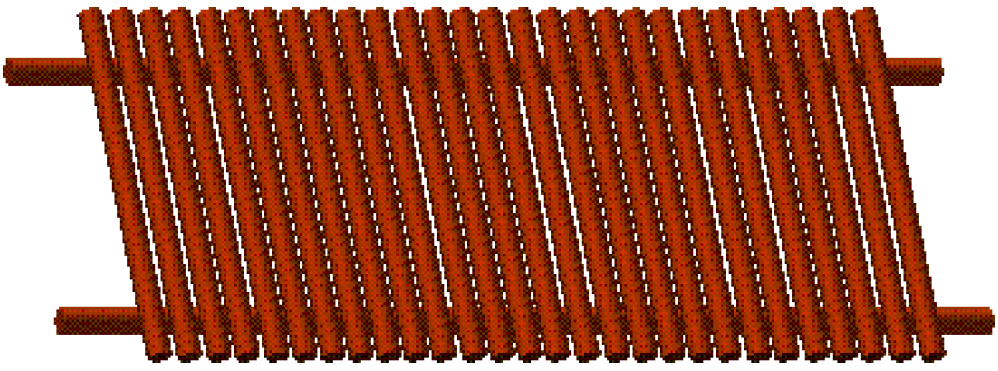
Many of the things you will build use ladders, platforms or ramps. These all are made in about the same way. The spars, ropes and lashings must be strong enough to “do the job.” Ladders need the strongest spars, ropes and lashings, because of the way people will climb on them. Table tops, seats, platforms and ramps need to have strong spars, but some of the ropes and lashings do not have to be very strong because they hold weight in a different way. Think of how the structure will be used. That will tell you how to build it. You climb ladders, walk on platforms and ramps, sit on seats or benches and put things on tables.

Each of the projects begins with a frame of two or four spars and has cross-spars lashed on top.



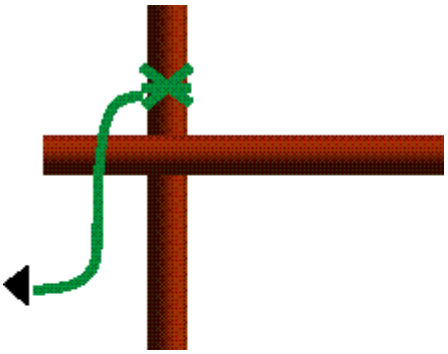
If the cross-pieces are spaced apart, you have a ladder.

If the cross pieces are placed next to one another, you have a ramp, platform, table top or seat.

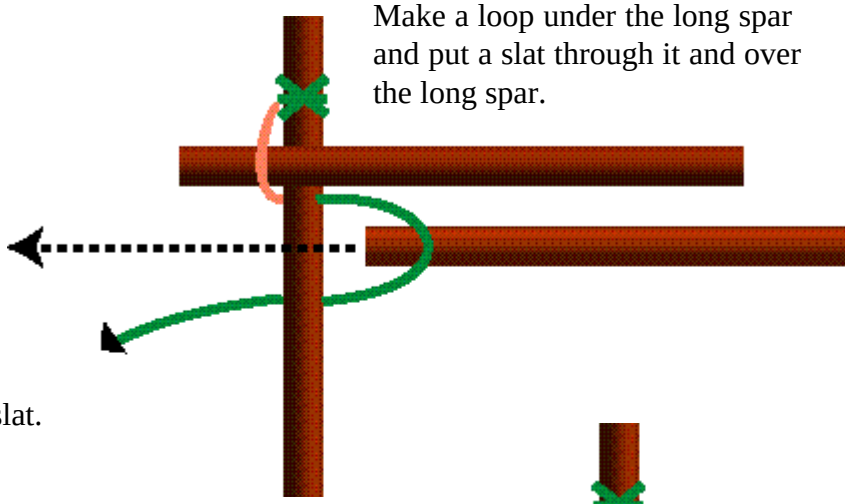


Ramps, platforms, seats or table tops need spars heavy enough to hold whatever weight you will put on them. The same is true for the rope. You can use square lashings for every joint, but for the "planks," the joint does not have to be so strong. Also, working with long ropes around so many cross pieces can cause tangles that make it hard to tie good lashings. There is a way of tying slats or planks to long spars without pulling the entire rope over and under the spars.

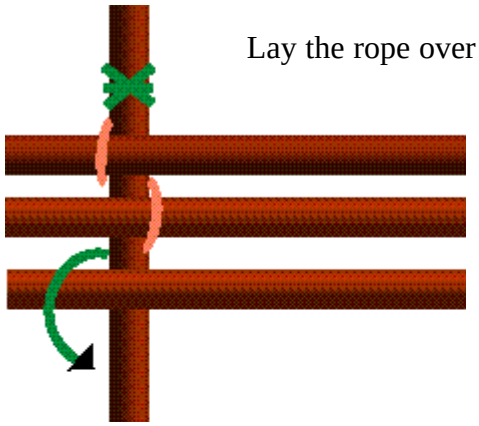
Begin with a clove hitch around a long spar, and tie the loose end off with a square knot, or pigtail. Put a plank across the long spar and lay the rope over the end as shown.



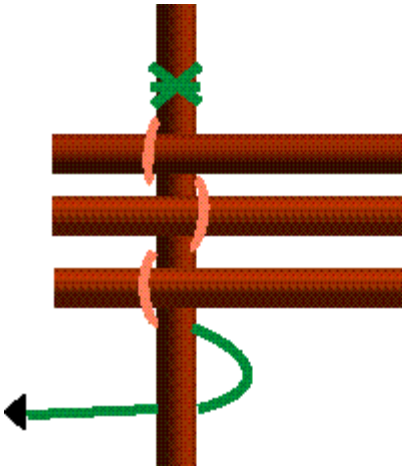
Make a loop under the long spar and put a slat through it and over the long spar.

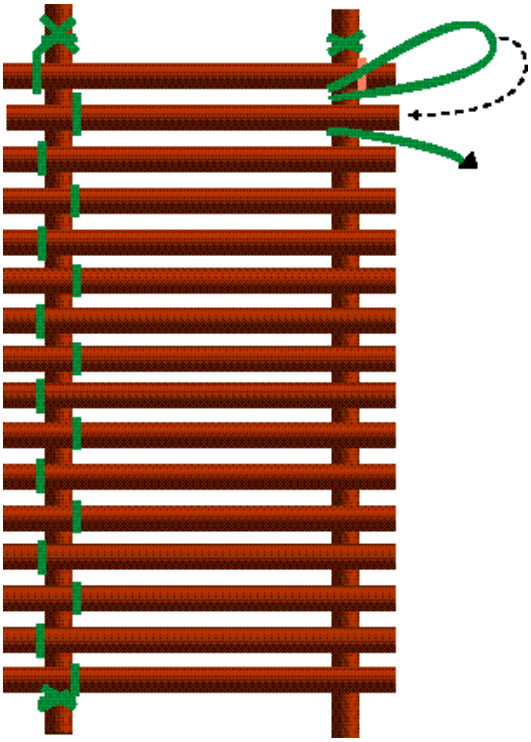


Lay the rope over a third slat.



Then repeat the second step for the fourth slat and so on, until you have reached the end. Finish with another clove hitch.





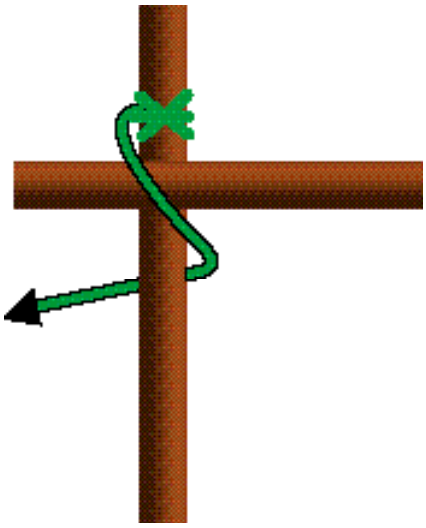
On the other side you will have to bring the "inside" loop over the slat already in place, but you can do that by using a little more rope from the free end. As you place each slat, push it up against the slat already there and tighten your rope. This lashing is not as strong as square lashing or ladder lashing, but it doesn't have to be. It is strong enough to hold the slats in place, and that is all that is needed. This way of lashing uses less rope and you do not have to weave the long rope in and out or over and around. The "inside" weaves are all done with loops!

This method can be used for bridge ramps, chairs, benches and table tops.

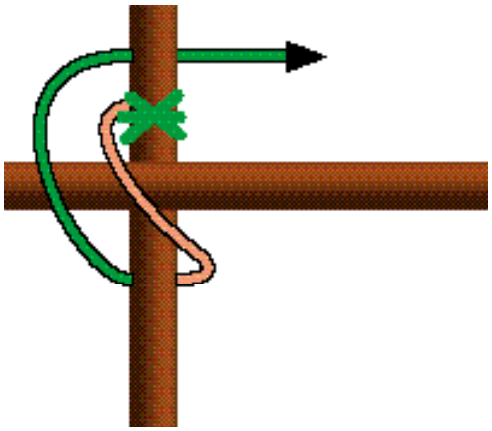
For ladders the spars used for rungs must be strong enough to support a person's weight The ropes and knots holding the "rungs" in place also must be very strong.

You can use square lashings for every joint, but that would take many short pieces of rope.

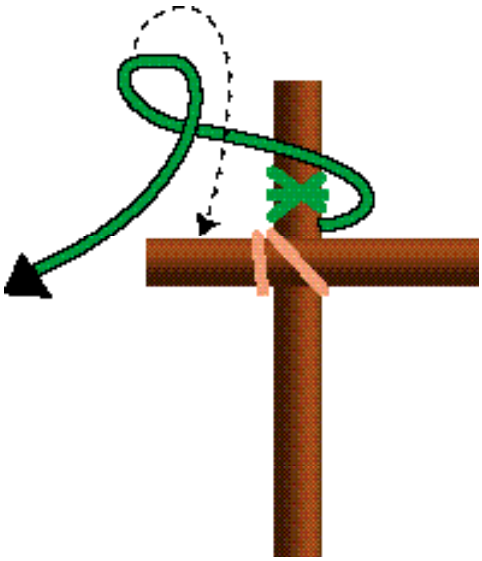
Here's a way of making a ladder using only two long pieces of rope -- but the lashings still are strong enough to hold a person's weight. Make sure that the long spars are heavy and long enough. Then tie the rungs on like this:



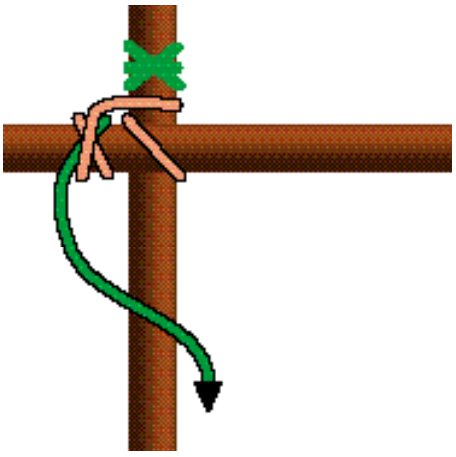
Begin with a clove hitch and tie the loose end off with a square knot. Lay a rung across and begin to wind the long (running) end around as shown.



At each turn, be sure to tighten the rope securely.



The last winding ends with an overhand loop placed on the end of the rung to form a half hitch.



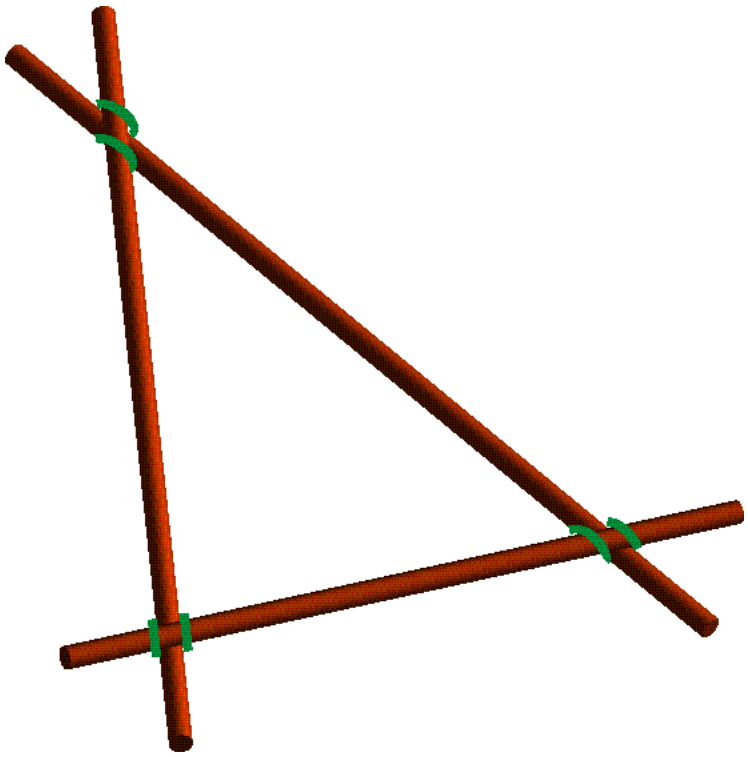
When you have finished, pull the rope very tight, bring it across the long spar and start with another rung. Continue down the long spar until all the rungs are in place, then finish the whole side off with another clove hitch. Repeat everything on the other side, and you're done.

For instructions on how to make a rope ladder, see the Brynbach Tower in Chapter IX.

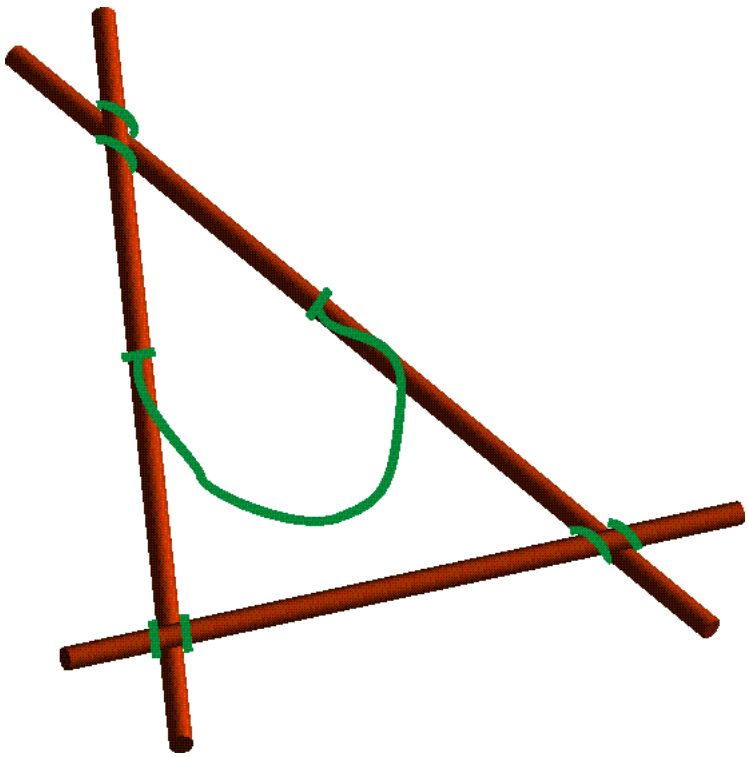
CHAPTER V
GAMES & CONTESTS

The Travois

These projects can be used for group games and contests. You can have fun building them, then see how strong they are when you use them. The first is based on the *travois* used by the Plains Indians to move their tepees and household goods as they followed the buffalo. It is made with three spars and four lengths of rope.



Begin by building a triangle using the three spars and three ropes. Use a square lashing at each corner. Make sure that the lower (base) spar is on top of the other two.



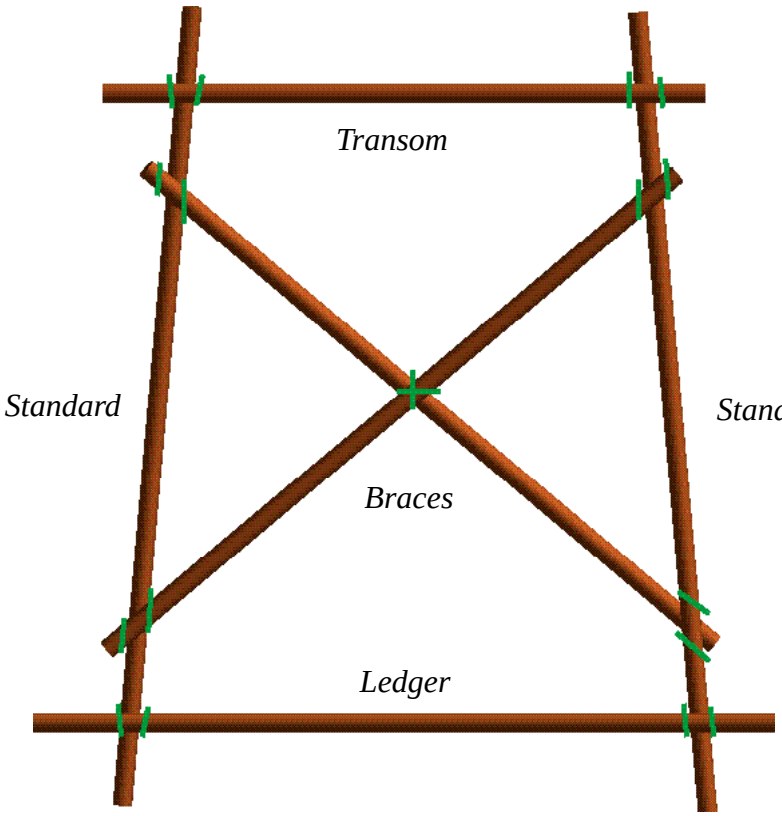
Then add the fourth piece of rope as shown using clove hitches.

One person is the “horse.” That one will stand inside the triangle at the top and pull it. The second person will stand on the bottom spar and hold on to the “reins” for balance. You can race against one another or just pull each other along.

Roman Chariot

Another version of the same game is the Roman Chariot. This one uses a design basic to many other structures, the "trestle." It is made with six spars and twelve ropes. It is a good idea to learn to make trestles well. They will be used in many other projects.

It's also a good idea to know the parts of a trestle. They have special names as shown in the picture below.

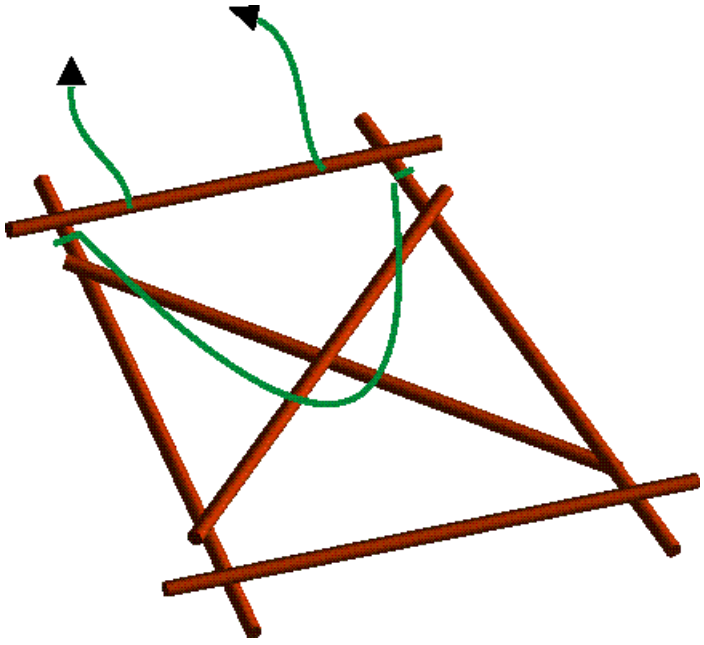


Lay the spars out as shown. Notice that the bottom spar is on top and that the center pieces are placed so that they will not touch where they cross. When you lash the structure together, use square lashings at every joint, except the center. There you will use a diagonal lashing in order to pull the two spars together.

Finish by using clove hitches to attach the *reins* and the two pull ropes or *traces*.

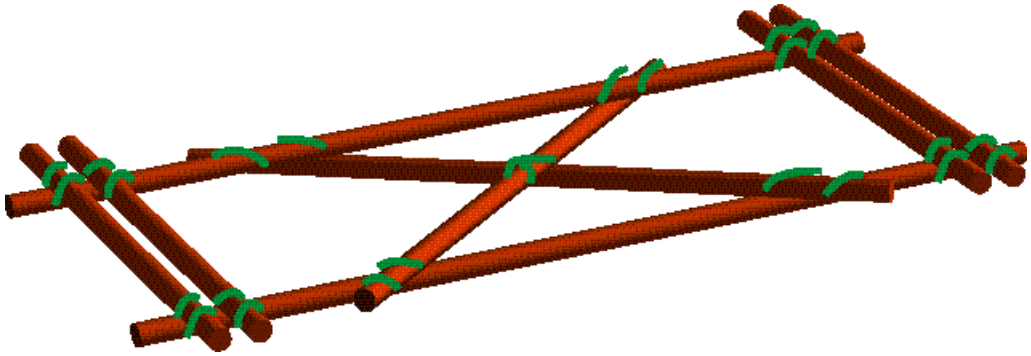
Again, one person stands on the lower spar and balances by holding onto the reins. Two or more other people pull the *chariot* along using the *traces* and the ends of the top spar.

Both the trestle and the triangle are very strong and stable. That is why they are used for many other structures.



Swing

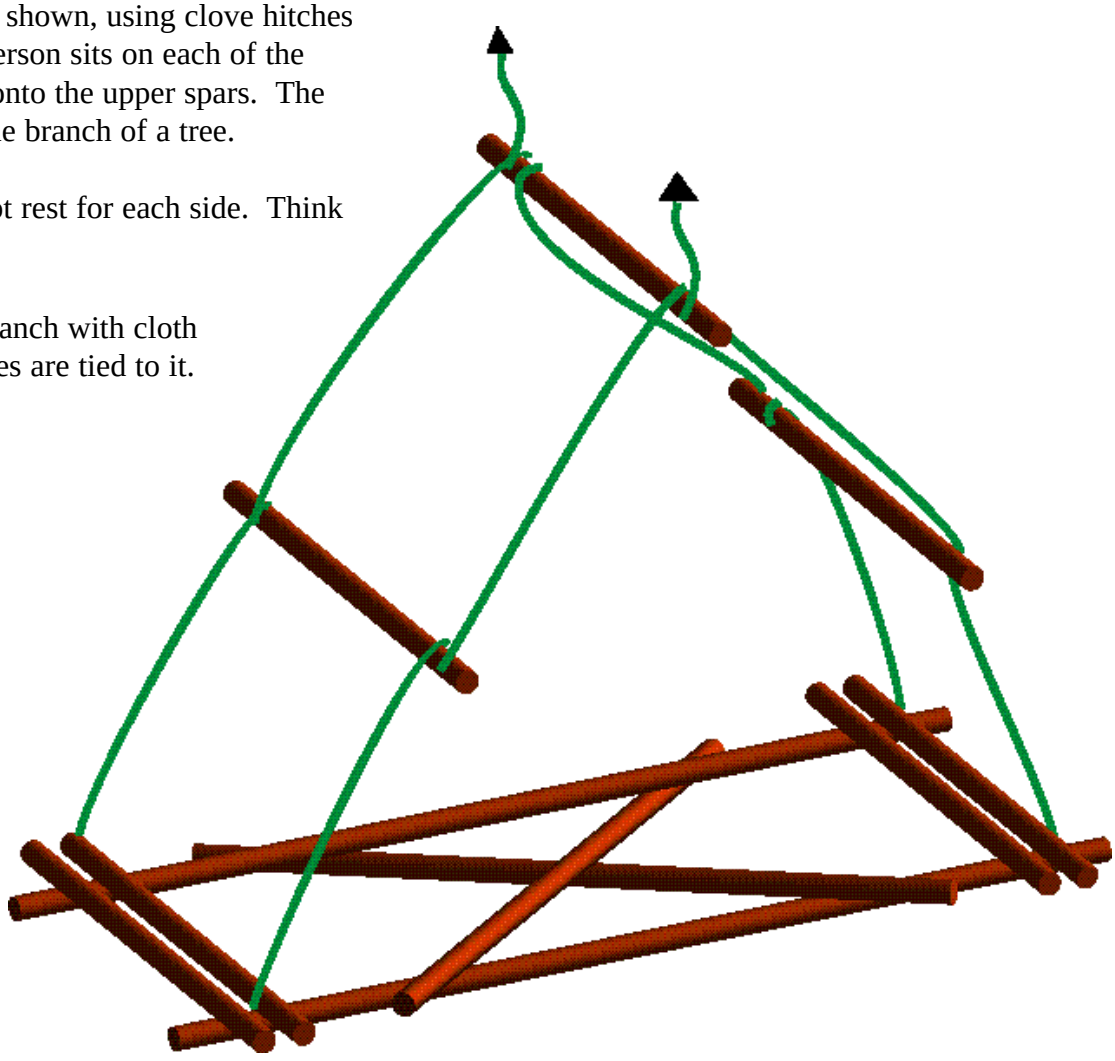
If you have a strong tree with spreading branches, you can make a two-person swing using the basic trestle design. First make a trestle, but with parallel edges and an extra spar at each end. Lash it together using a diagonal lashing in the center and square lashings everywhere else.



Then add three spars, as shown, using clove hitches to attach the ropes. A person sits on each of the double spars and holds onto the upper spars. The top spar is attached to the branch of a tree.

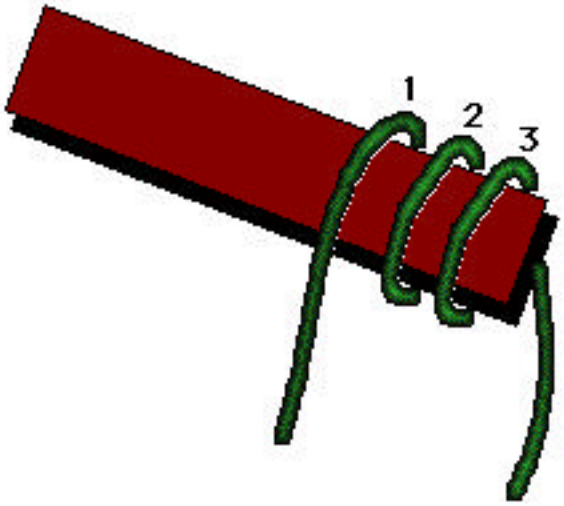
You also can make a foot rest for each side. Think of how you could do it.

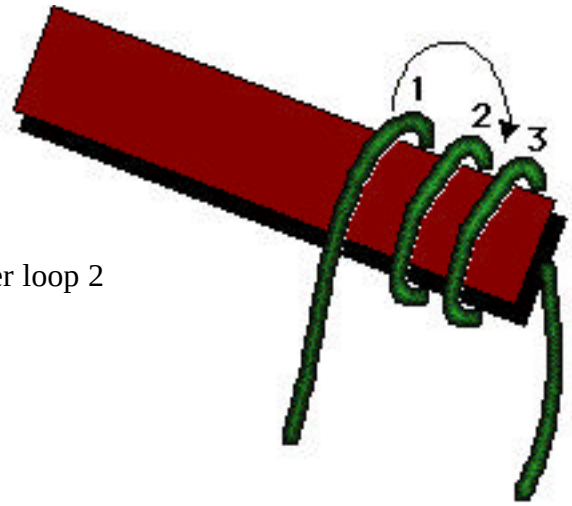
Remember to pad the branch with cloth or leather where the ropes are tied to it.



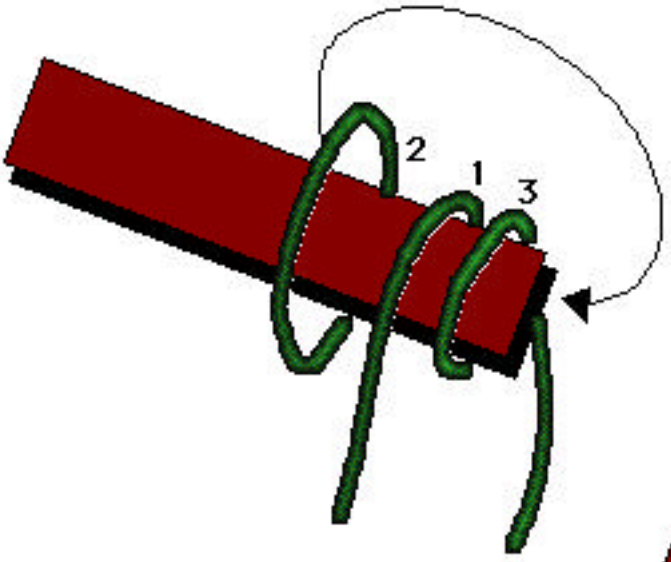
A swing for one person can be made from a 1 (or 2) x 6-inch plank and rope.

First wrap the rope around the board three times as shown.

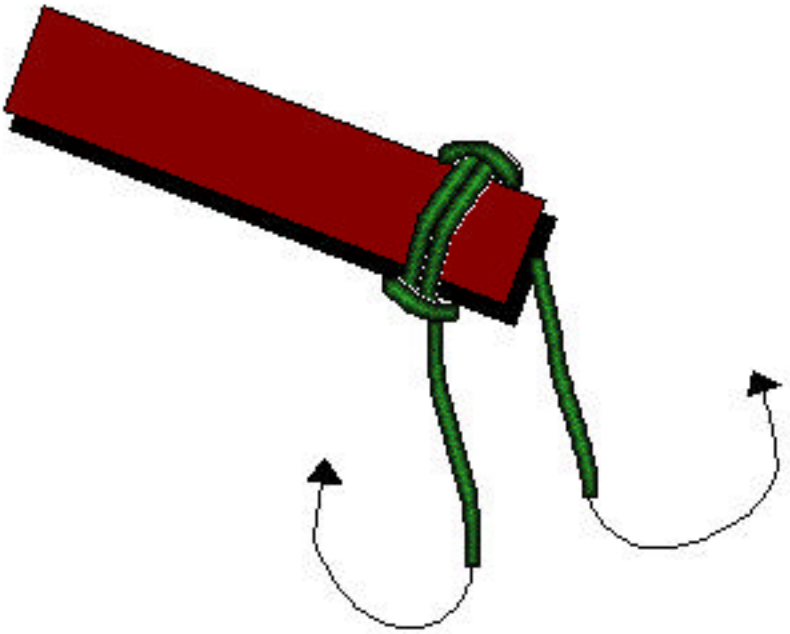




Pull loop 1 over loop 2

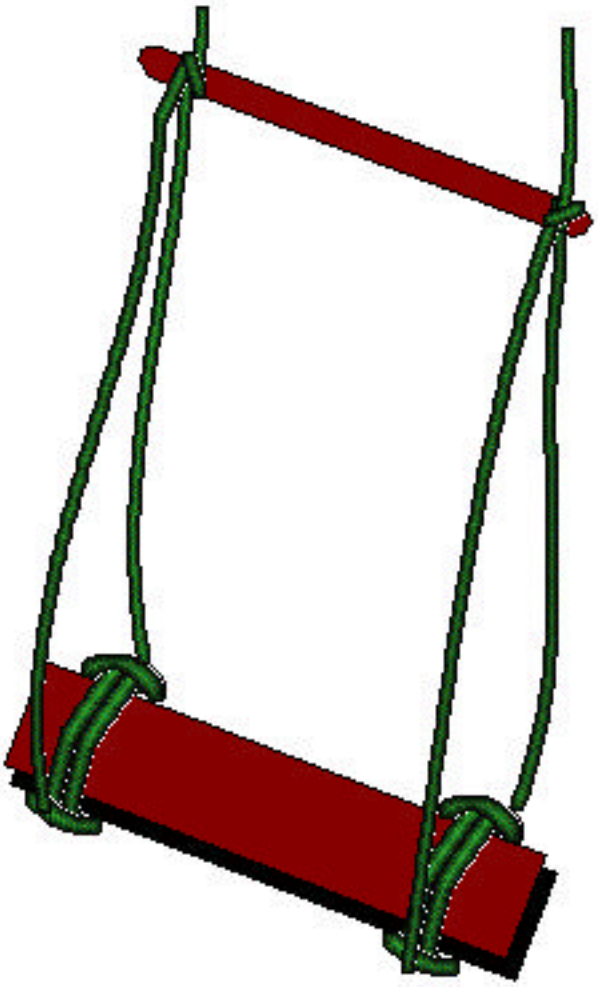


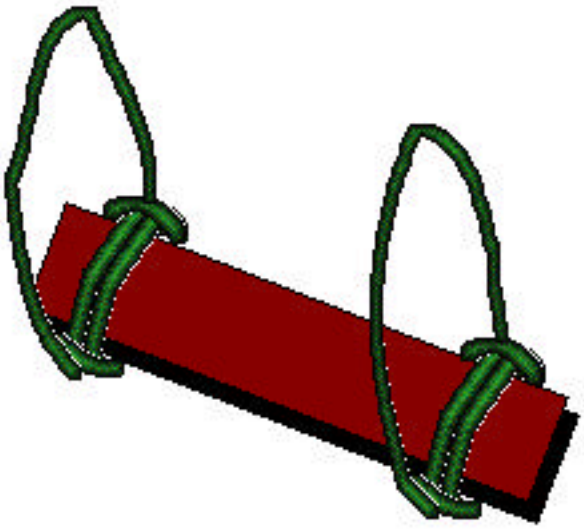
Then pull loop 2 over the end of the board.



When you have finished, this is what it will look like.

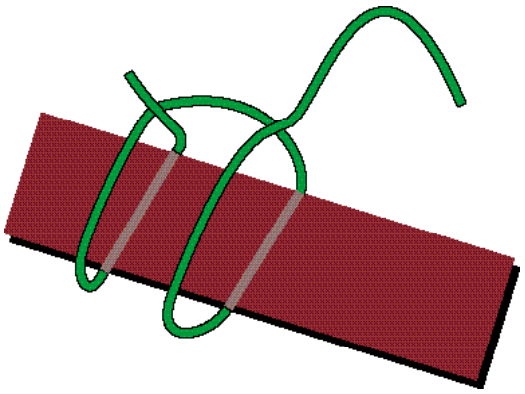
Do the same thing at the other end of the board, then tie all four ends to a single spar, and attach that spar to the tree branch.





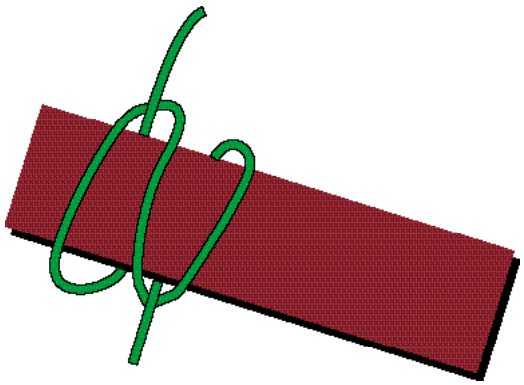
If you tie the four ropes together as shown instead of to a spar, you can have another race. Make them short enough so that if you hold them in the middle and stand at the end, the board should be about six inches off the ground. With a person at each end, holding onto the ropes, a third person stands on the board balancing by holding the shoulders of the “carriers.” Teams of three people can race this way.

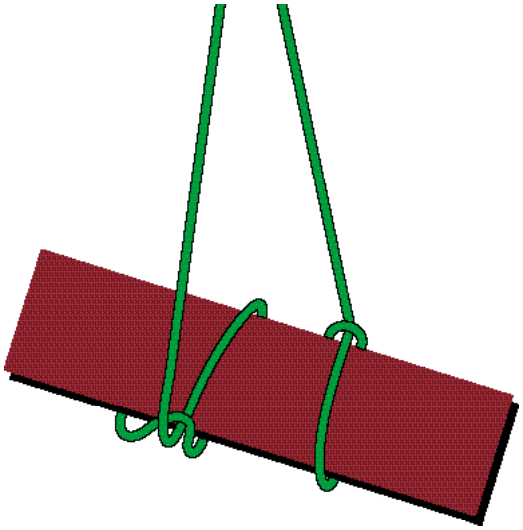
Another way of making a swing seat is based on the clove hitch.



Tie a clove hitch loosely around one end of the seat.

Pull the rope ends to opposite sides -- down and away from the seat.





Turn the seat over and continue pulling the ends of the rope up until you can tie one to another. Then attach them to the branch. Do the same on the other end of the seat.

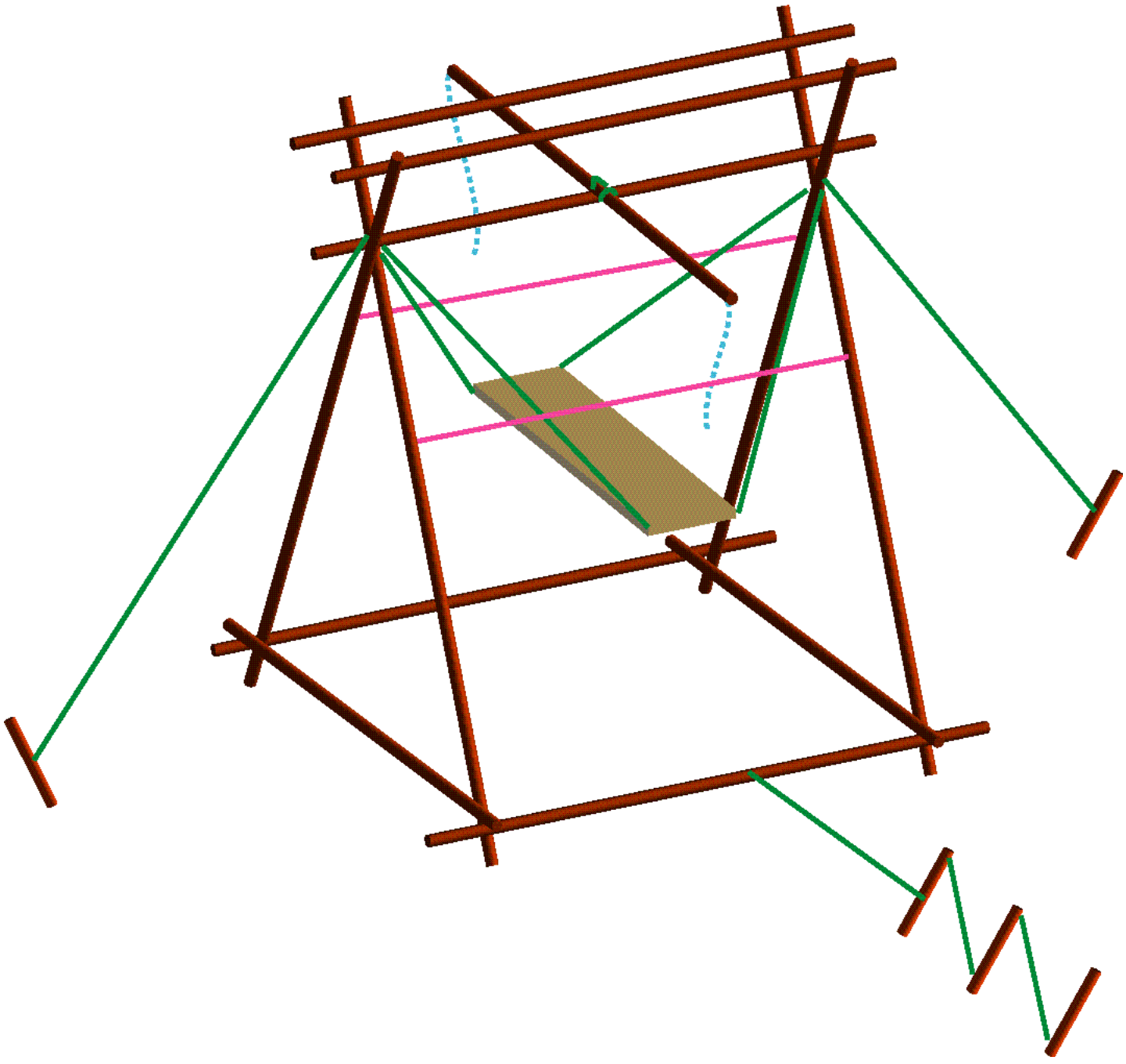
Remember to pad the branch.

Swing Boat

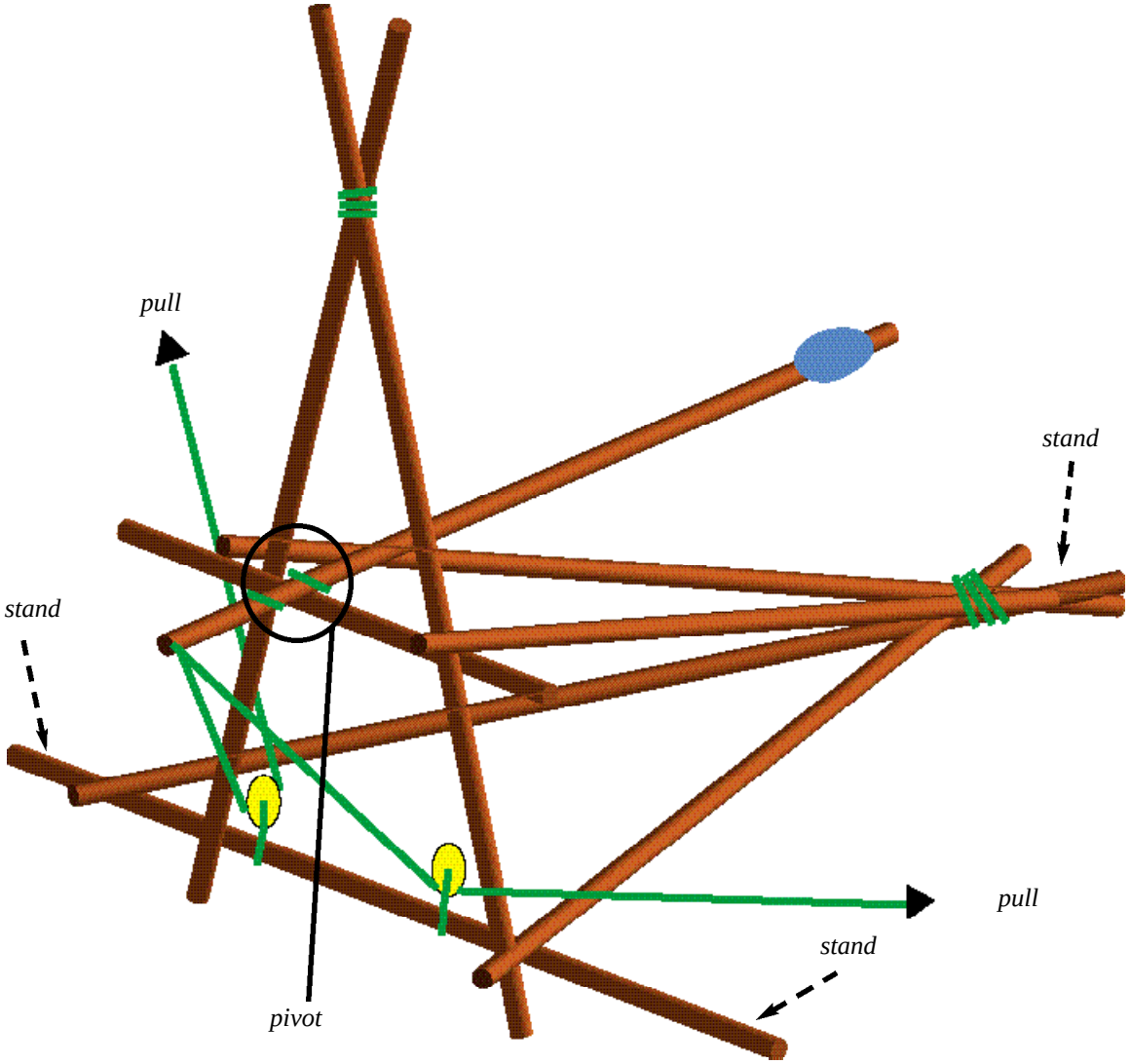
When you don't have a tree with a strong branch to use, you have to make your own "tree." Here you use two triangles and five long, strong cross-spars. Lash another shorter spar to the two top cross spars and tie ropes (blue) to each end to use as pulls. A plank forms the seat with four ropes to tie it to the "tree." Finally, two more ropes (pink) are tied between the bipods to keep the swing from going too high.

This swing looks hard to make, but if you look at each of its parts, it is really simple. Make one part (like a triangle) at a time, then lash all the parts together.

Finally, notice that the whole structure is well staked to keep it from moving. (One set of stakes is not shown.). See the X-Bridge in Chapter VI and Useful Tools (Chapter XII) to see how to stake out structures.



Catapult



This catapult is made by lashing a triangle out of strong spars. Make sure that the bottom spar is long enough so that someone can stand on each end. A second triangle is made by using the bottom cross-spar and two more long spars that lie on the ground to finish forming the base of the catapult. A third triangle forms the pivot. Lash a strong cross-spar about halfway up the first triangle. Finish it off with two spars going from there to the ground in back. One final spar lies loosely lashed to the middle cross-spar. In back tie a can or something else that will be your launch pad. In front tie two lines that will lead to pulleys on the lower cross spar, then go off to either side.

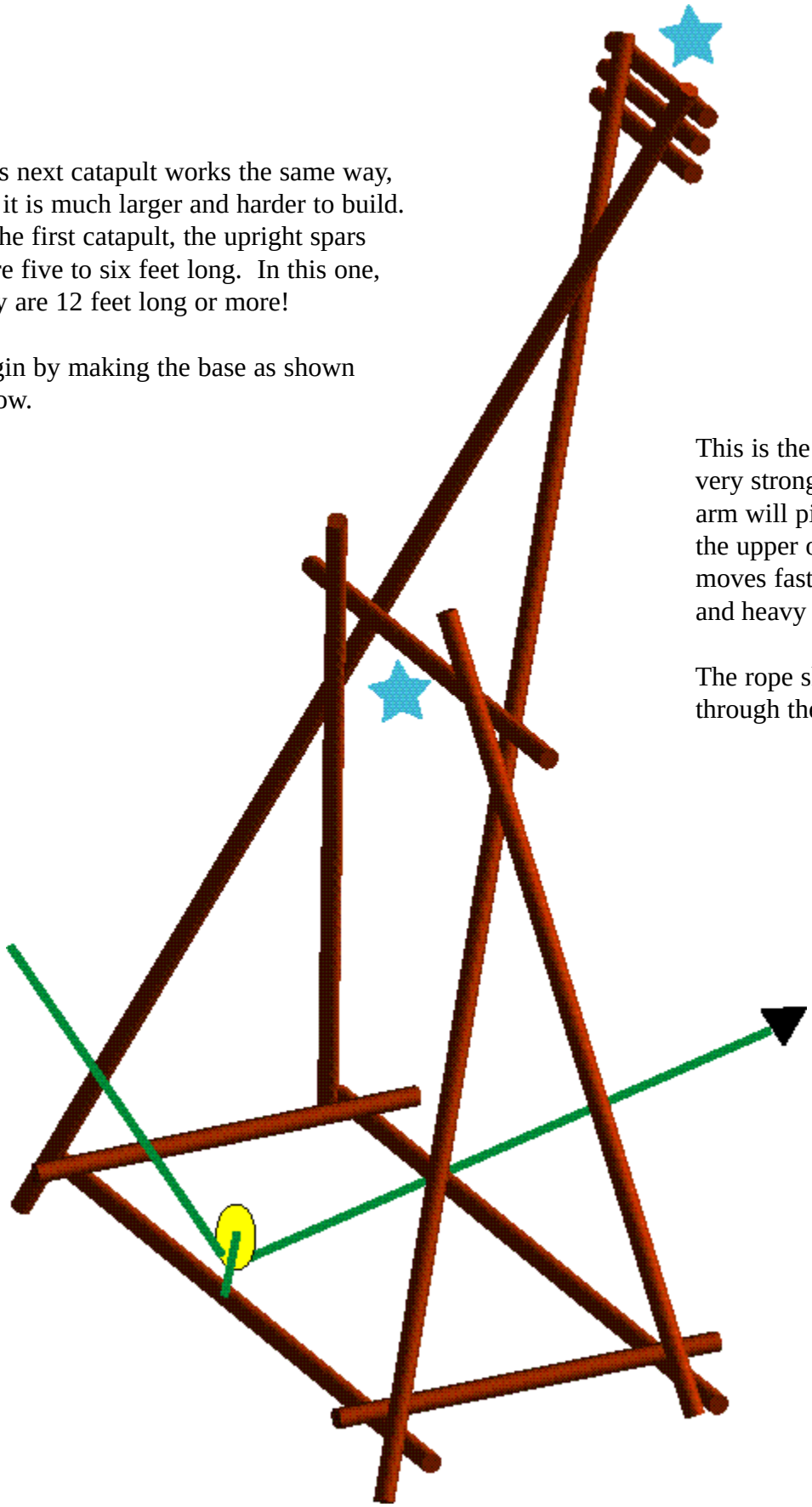
It takes five people to use this catapult. Three people stand at the points marked on the drawing to hold it in place. Two more people will stand off to the sides and pull the ropes. As they do this the spar will pivot around the middle cross-spar until it hits the top. At that point, whatever was on the other end will be thrown up and forward.

You can adjust the arc of the catapult by leaning the upright triangle forward or backward. Backward will give you a higher arc; forward, a lower arc. If the triangle is too far forward or backward, you will not be able to get much distance. Instead of using water “balloons,” fill plastic zip-lock bags with water. They work much better and can be re-used.

Trebuchet

This next catapult works the same way, but it is much larger and harder to build. In the first catapult, the upright spars were five to six feet long. In this one, they are 12 feet long or more!

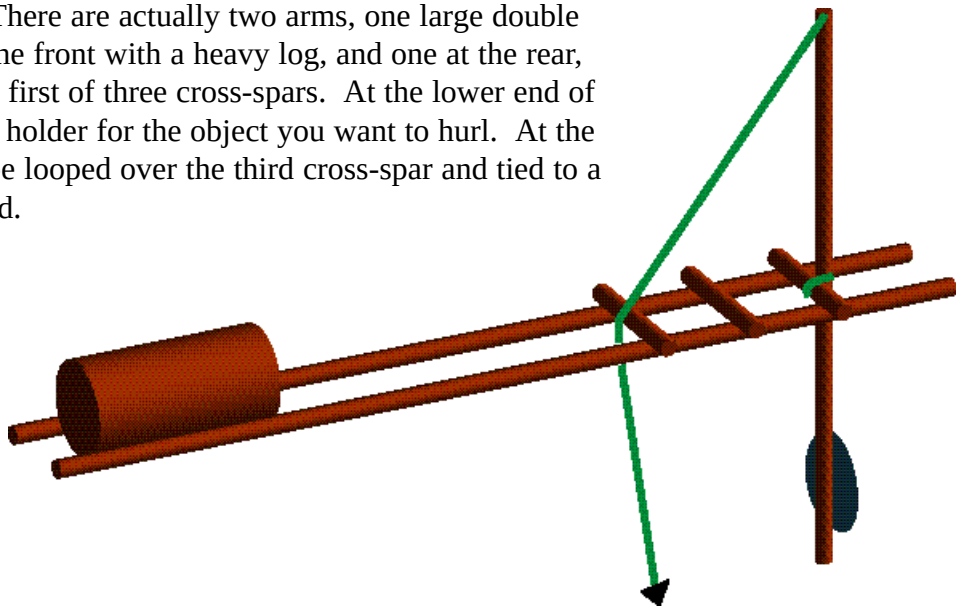
Begin by making the base as shown below.



This is the support structure. It must be very strong. Notice the two blue stars. The arm will pivot on the lower one. It will hit the upper one. The arm is heavy and moves fast, so you must use strong spars and heavy rope.

The rope shown is tied to the arm, goes through the pulley and leads off to the back.

This is the arm. There are actually two arms, one large double arm weighted at the front with a heavy log, and one at the rear, tied loosely to the first of three cross-spars. At the lower end of the small arm is a holder for the object you want to hurl. At the upper end is a rope looped over the third cross-spar and tied to a stake in the ground.



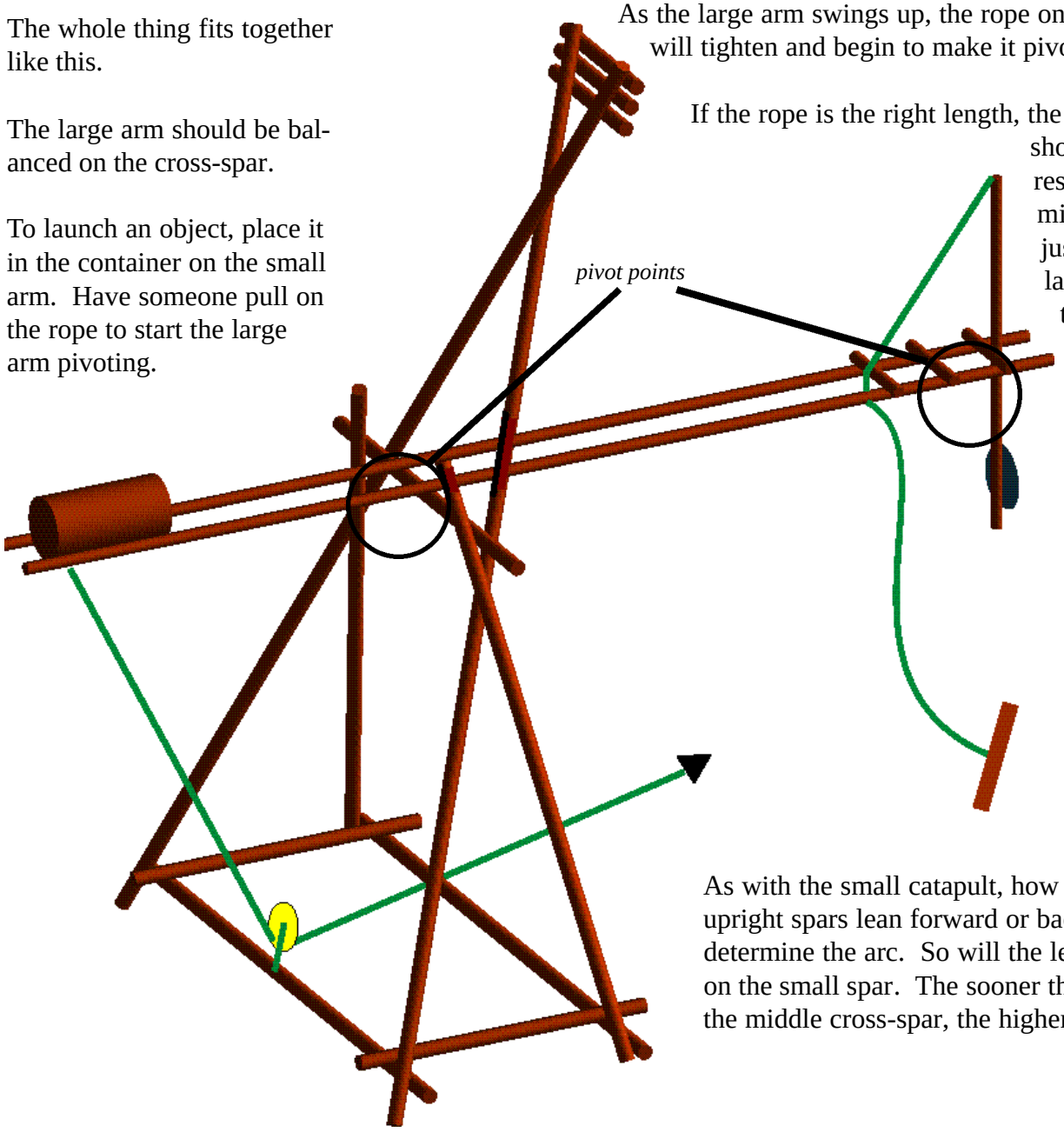
As the large arm swings up, the rope on the small arm will tighten and begin to make it pivot as well.

The whole thing fits together like this.

The large arm should be balanced on the cross-spar.

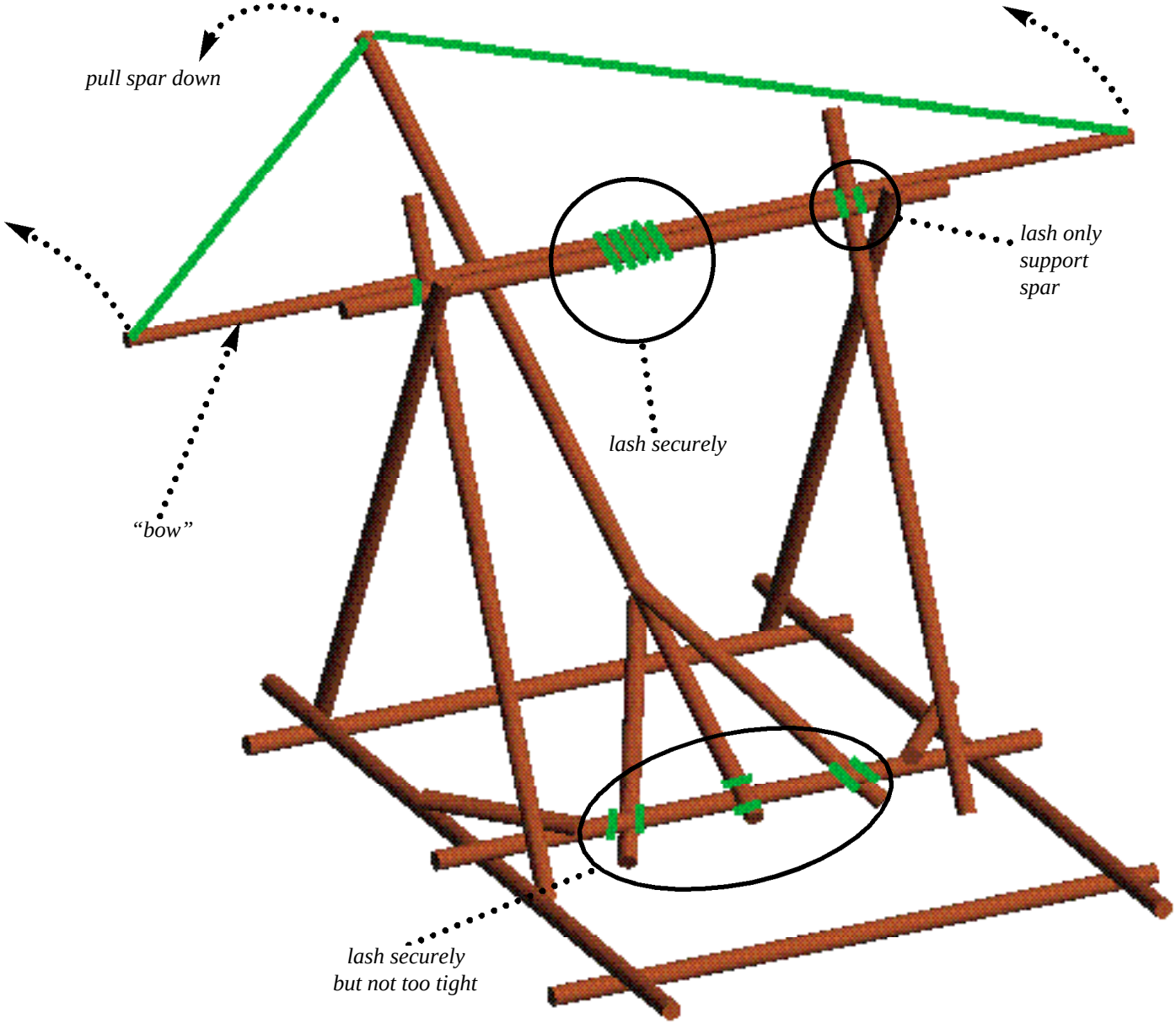
To launch an object, place it in the container on the small arm. Have someone pull on the rope to start the large arm pivoting.

If the rope is the right length, the small arm should come to rest against the middle cross-spar just before the large arm hits the top. This gives added force to the throw.



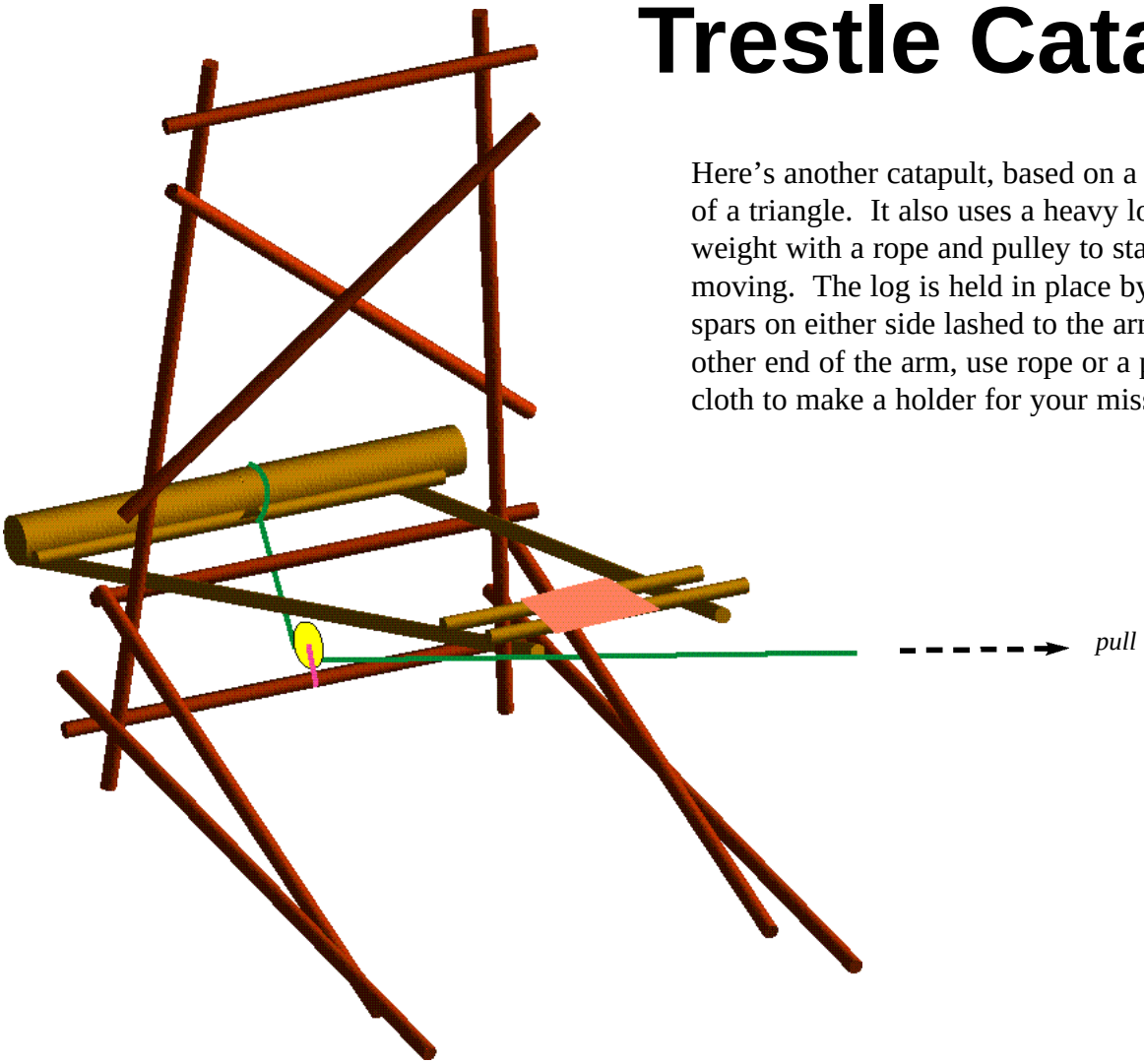
As with the small catapult, how much the tall upright spars lean forward or backward will determine the arc. So will the length of the rope on the small spar. The sooner the small spar hits the middle cross-spar, the higher the arc will be.

“Bow” Catapult



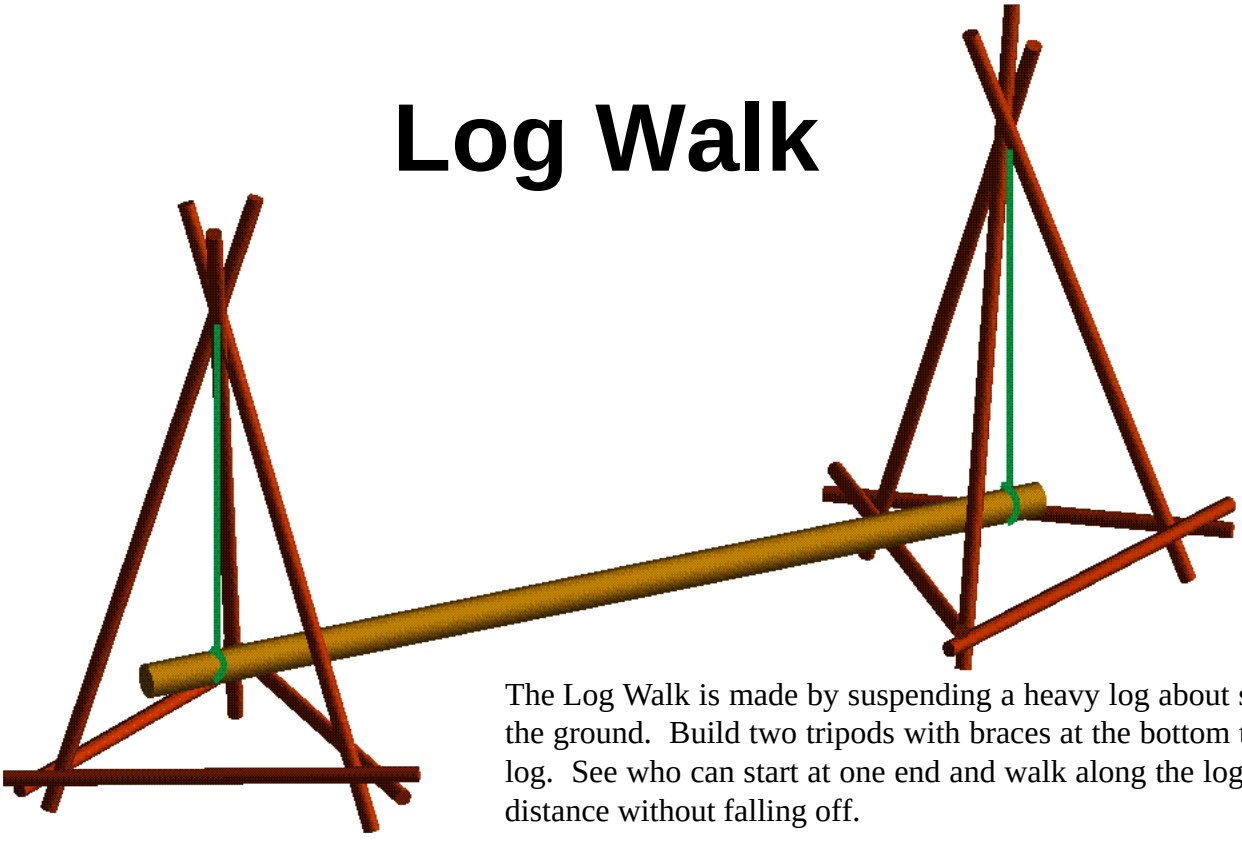
The Bow Catapult uses a long spar that is stiff and strong, but bends and springs back without breaking. Tie it securely to the center of the support spar. Attach two ropes from either end to the throwing arm. The bottom of the throwing arm should be lashed securely, but not too tight, so that it will pivot easily. The four corners of the base should be staked down.

Trestle Catapult



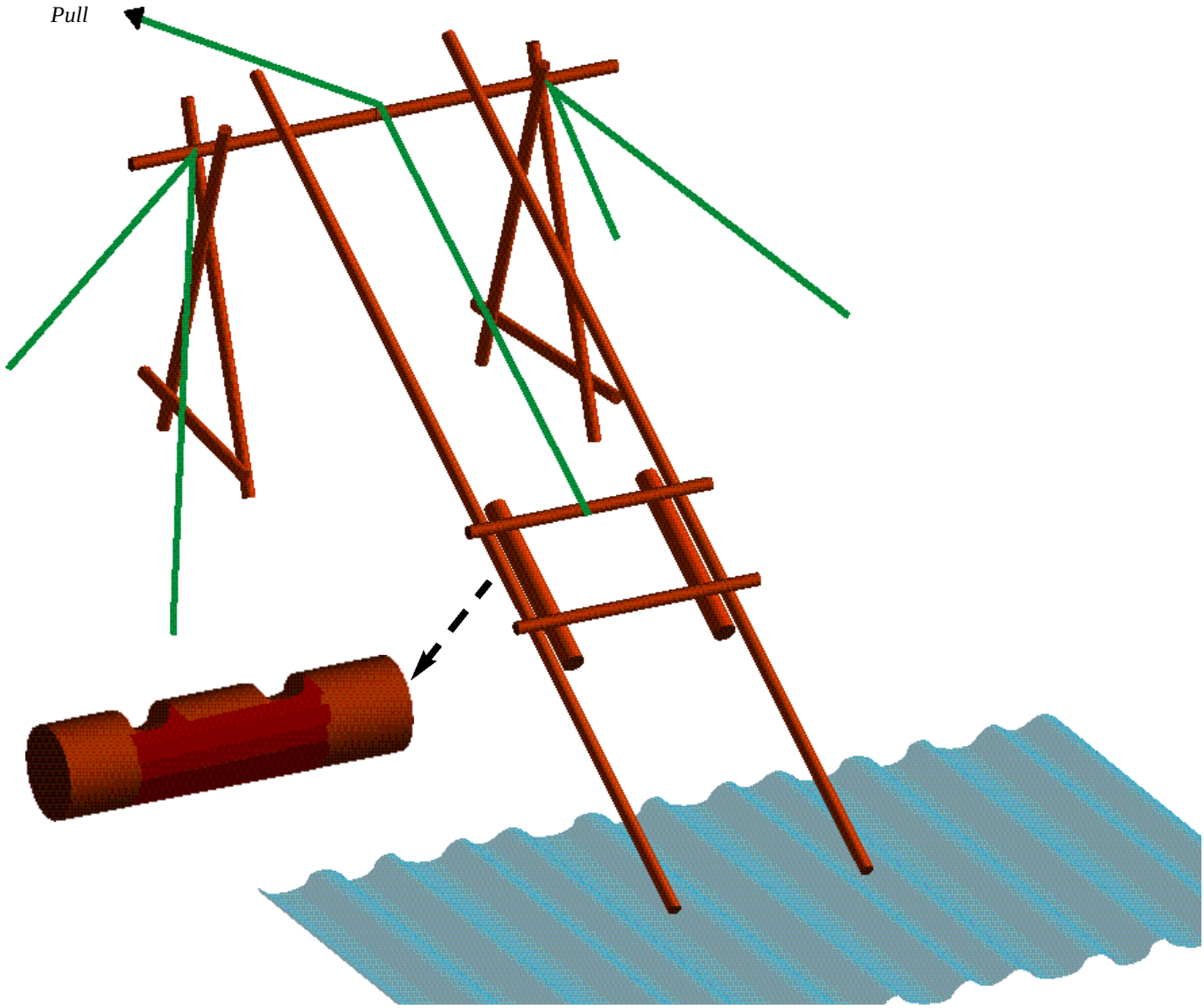
Here's another catapult, based on a trestle instead of a triangle. It also uses a heavy log as a counter-weight with a rope and pulley to start the arm moving. The log is held in place by two smaller spars on either side lashed to the arms. At the other end of the arm, use rope or a piece of heavy cloth to make a holder for your missile.

Log Walk



The Log Walk is made by suspending a heavy log about six inches off the ground. Build two tripods with braces at the bottom to hold the log. See who can start at one end and walk along the log the greatest distance without falling off.

Water Chute



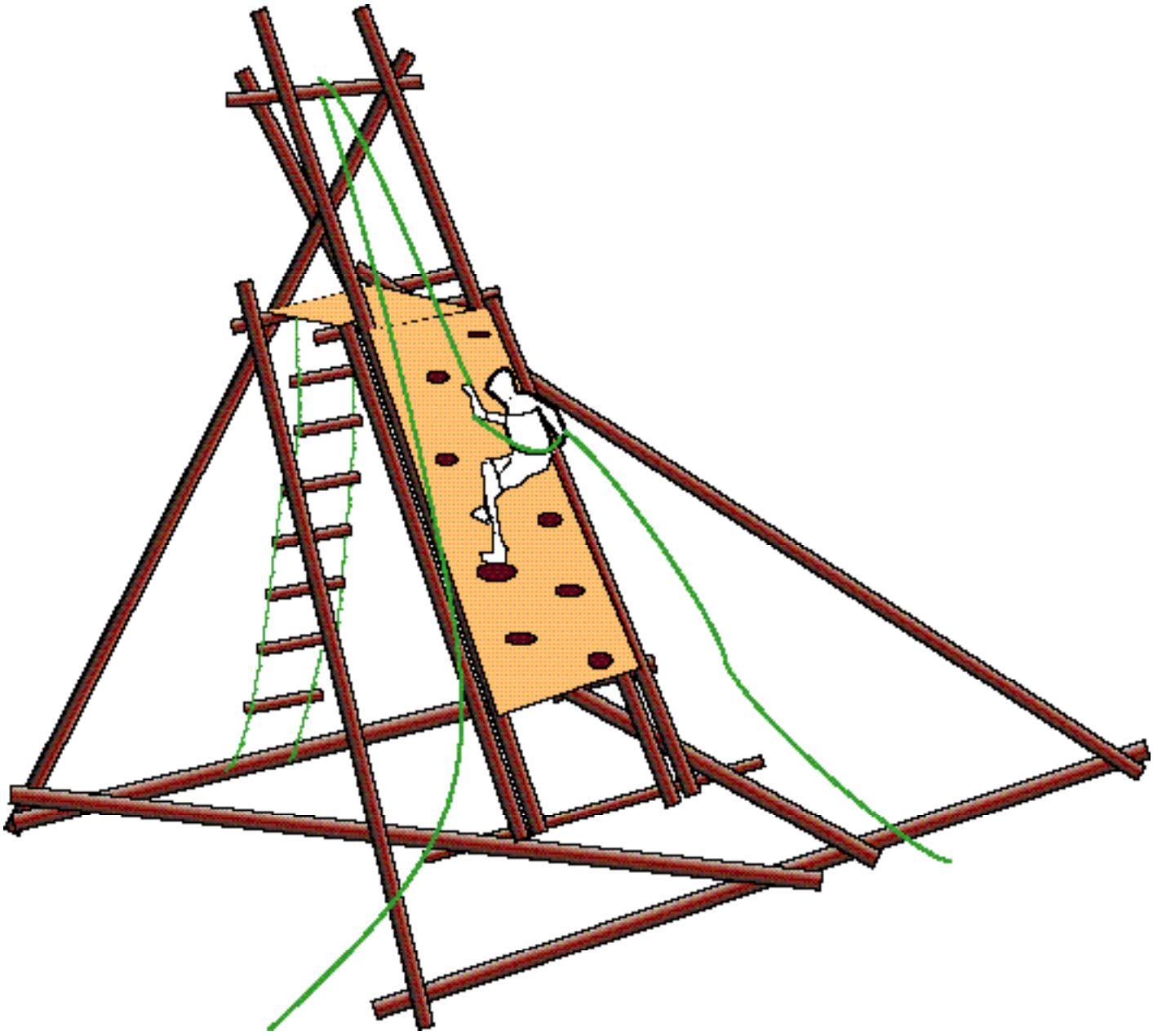
The Water Chute has three parts. The first is the base that supports one end of the slide. It is made with two triangles and a long cross-spar. The base and its spars have to be strong enough to support your weight and not become loose when you climb on it and use the slide. Brace it well with lines and stakes.

The second part is the slide. It is made from two long spars. These spars must be strong too and well anchored into the bottom of the lake or river. Also, they need to be as smooth and even as possible so that the seat will slide down easily.

The last part is the seat. It is made from two heavy spars (notched, as shown) and at least two cross-spars. You also can use another two spars lashed to the seat on the outside of the slide to keep the seat from coming off the slide (not shown).

A rope tied to the seat and passed over the cross-spar can be used to pull the seat back to the top. Climb to the top of the base, sit on the seat and let go!

Climbing Wall

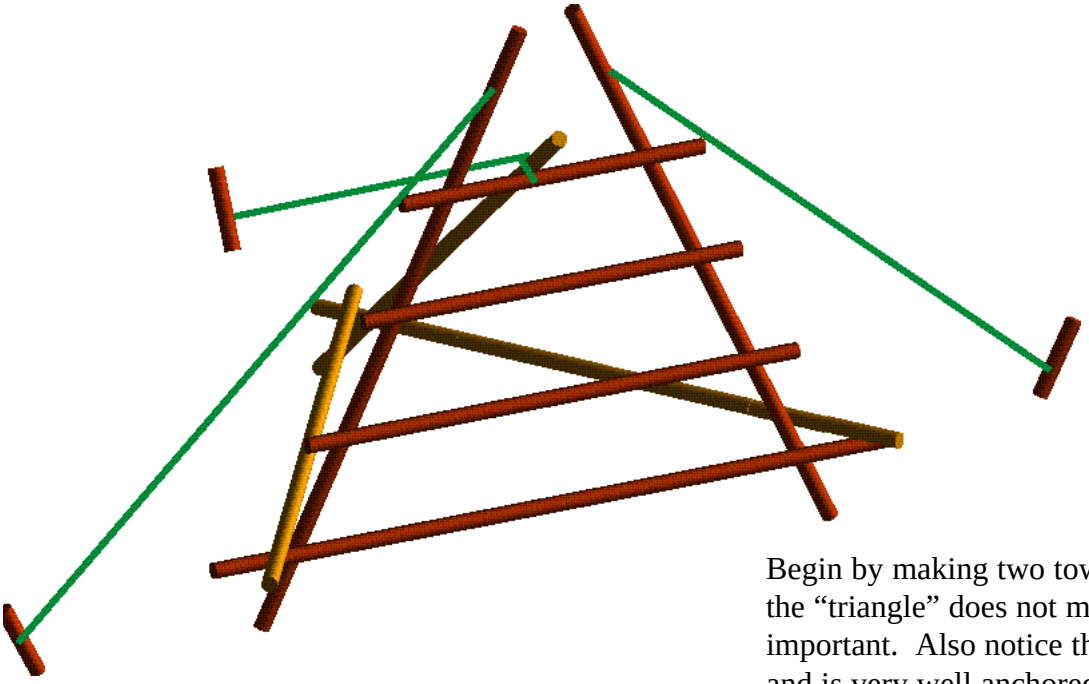


With long and heavy enough spars you can build a climbing wall. For the wall itself, use 5/8-inch plywood bolted to the supporting spars. Be sure to tie the rope ladder (see the Brynbach Tower) to the bottom as well as the top. Always wear a helmet when climbing and have someone to “belay” you -- holding on to the end of the rope so that if you slip, you will not fall. When you begin to build and climb towers in Chapter IX, you also should wear a helmet and have someone to belay you.

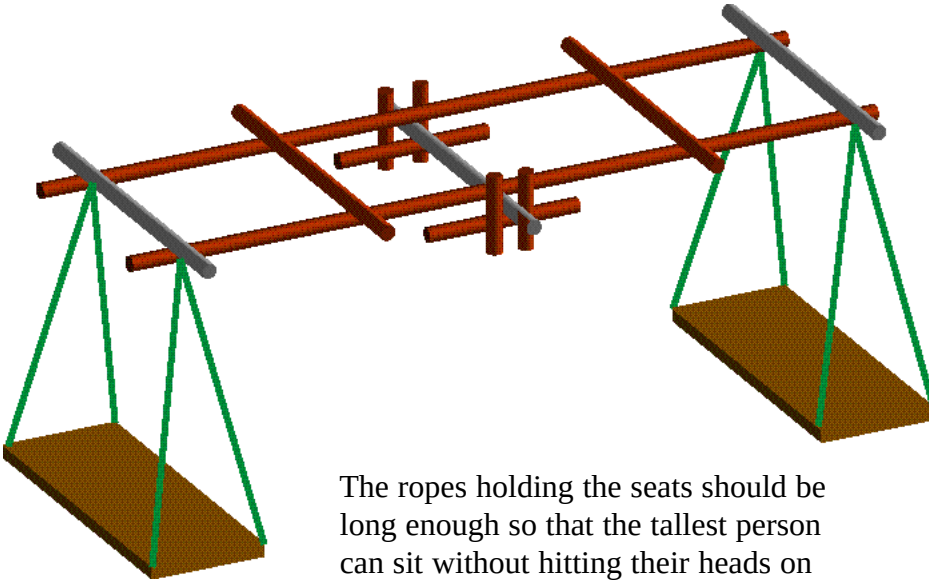
The Luxembourger

These last two projects use some special metal parts that must be custom made. However, they can be used over and over again.

The Luxembourger is a two-person Ferris Wheel.



Begin by making two towers as shown. Notice that the "triangle" does not meet at the top. This is very important. Also notice that it has many extra braces and is very well anchored.

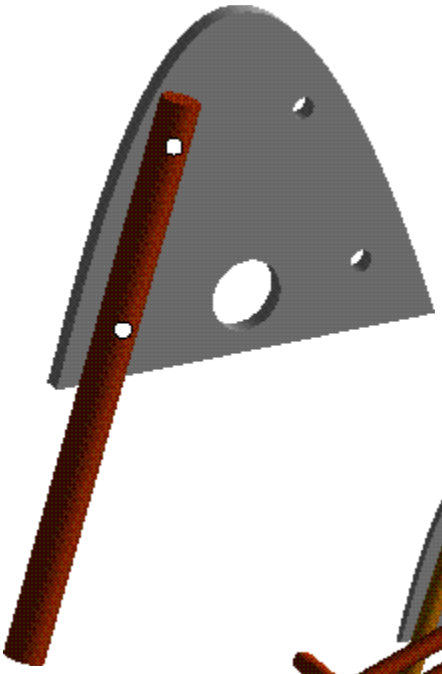


This next part will fit between the two towers and revolve around the center spar. Notice that it and the two end spars are gray. That is because they are steel or iron rods. Wood spars are not strong enough to hold all the weight.

The center metal rod is held in place by making spar "boxes" around each end. These must be *very* securely lashed!

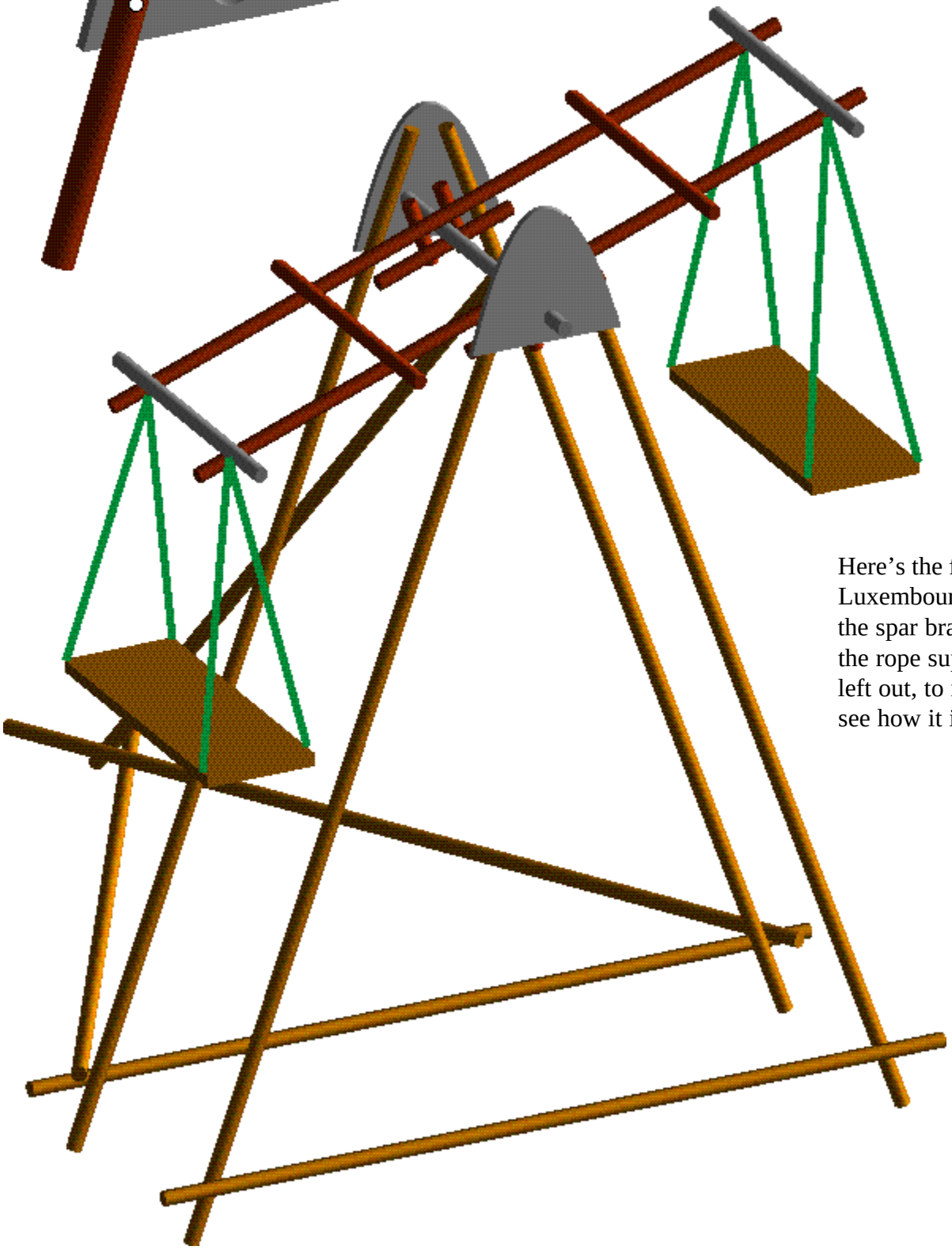
The ropes holding the seats should be long enough so that the tallest person can sit without hitting their heads on the metal bar.

Also the two wood cross-spars should be close enough to the middle that the person's feet do not hit it as the structure rotates.



Remember that the long upright spars of the triangles did not meet? They are each joined together with a metal plate. Each plate (one is shown to the left) has one large hole to hold the center metal rod and four smaller holes. Use these to bolt the plates to the top of the triangles.

The size of the rods depends on what they are made of and how much weight they will need to support. The center rod, however, needs to be at least two inches in diameter.

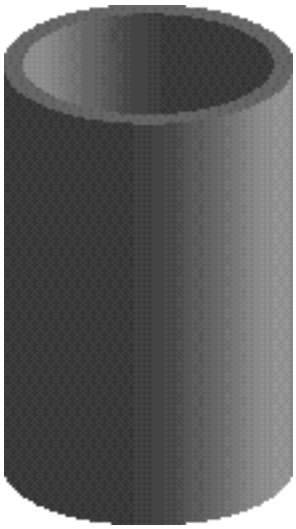


Here's the finished Luxembourger. Some of the spar braces and all of the rope supports have been left out, to make it easier to see how it is built.

Merry-Go-Round

And finally, here's another project that requires special parts. You need two metal cylinders, large enough to fit around a telephone pole.

The first should look like this:



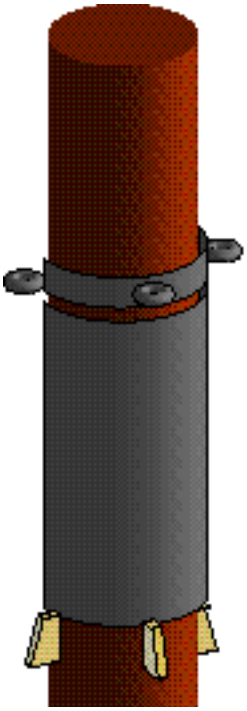
Sleeve

And the second, like this:

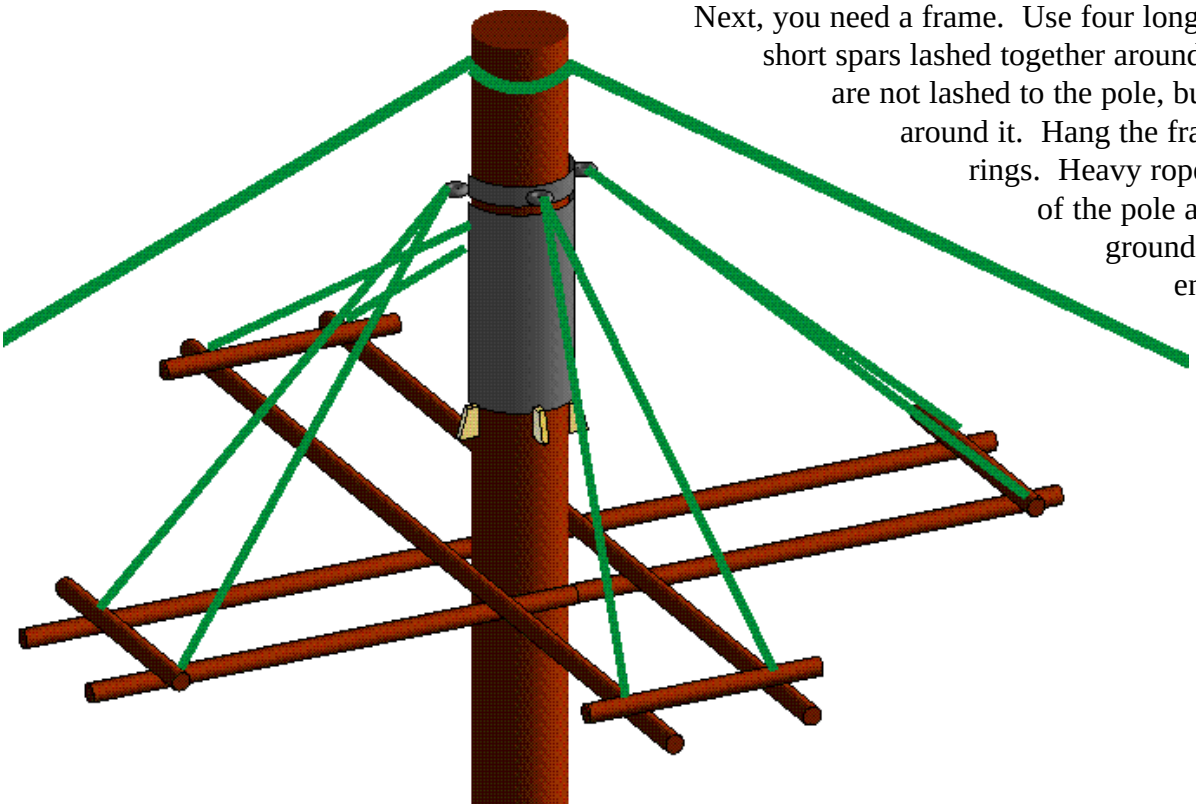
Top Ring

It should have the same internal and external diameter as the sleeve and have four rings welded around the outside.

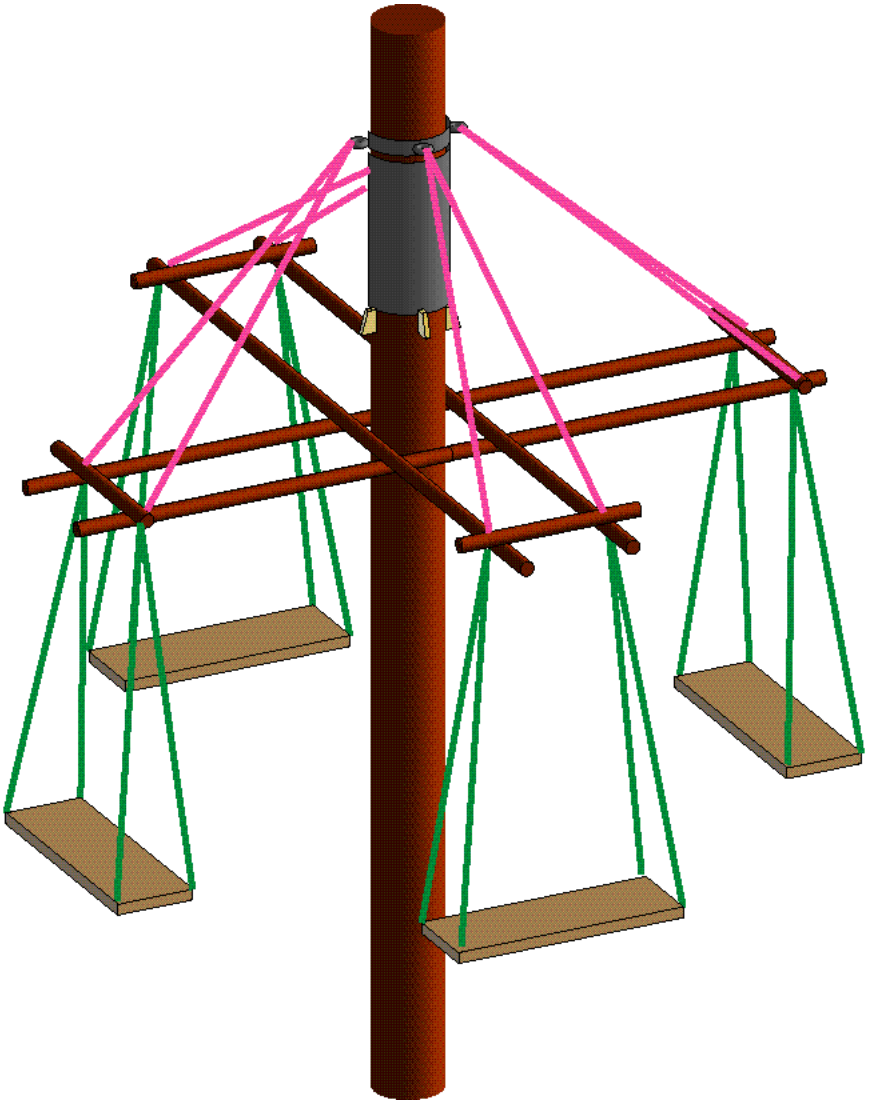
The two parts fit together on the pole like this:



The ring is placed above the sleeve. It moves freely around the pole. The sleeve is held firmly in place by "shims," small wedges made of wood that are driven between the sleeve and the pole. The sleeve does not move. It supports the weight of the Merry-Go-Round.



Next, you need a frame. Use four long spars and four short spars lashed together around the pole. They are not lashed to the pole, but move freely around it. Hang the frame from the four rings. Heavy ropes tied to the top of the pole and staked into the ground far outside the ends of the frame will help keep the Merry-Go-Round steady. Use as many as needed to keep the center pole from wobbling.



The last step is to add the seats. They hang from the ends of the frame as shown. The whole structure will revolve around the center pole when any seat is pushed.

You also can turn the Merry-Go-Round with long ropes tied to the ends of the frame. Four people ride the seats and someone stands outside and pulls the rope around the pole.

CHAPTER VI
BRIDGES

Basic Bridges

There are many different kinds of bridges you can build; some are easy, some more difficult. They all are fun to build and use. You can put a bridge across a stream or gully -- or even in your yard to play on.

Because you will be walking across these bridges, there are a few things to remember.

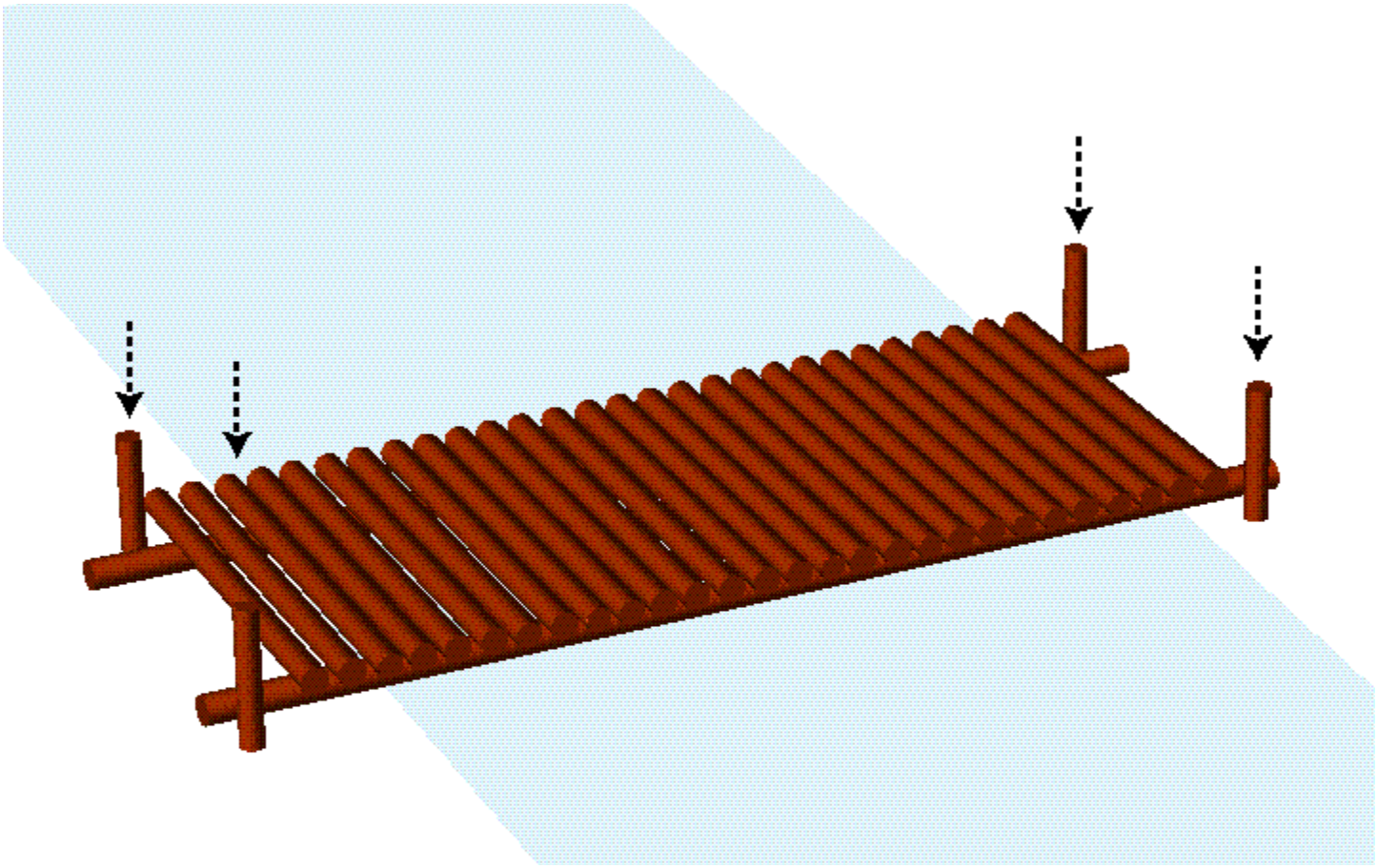
1. The most important is that the bridge must be strong enough to hold many people at once without breaking. For that you need very strong spars and planks.

2. The bridge must be anchored firmly and the lashings must be very tight, so that it will be stable and not move. Movement makes a bridge unsteady. It also loosens the lashings. That will make the bridge unsafe.

The easiest bridge to make uses a ramp. (See Chapter IV on ladders.) Make it long enough to go across the stream or gully with at least a foot extra on each end.

The rope used to lash the planks does not have to be heavy, because they and the long spars bear all the weight, but the lashings must be very tight so that they do not loosen as people walk across.

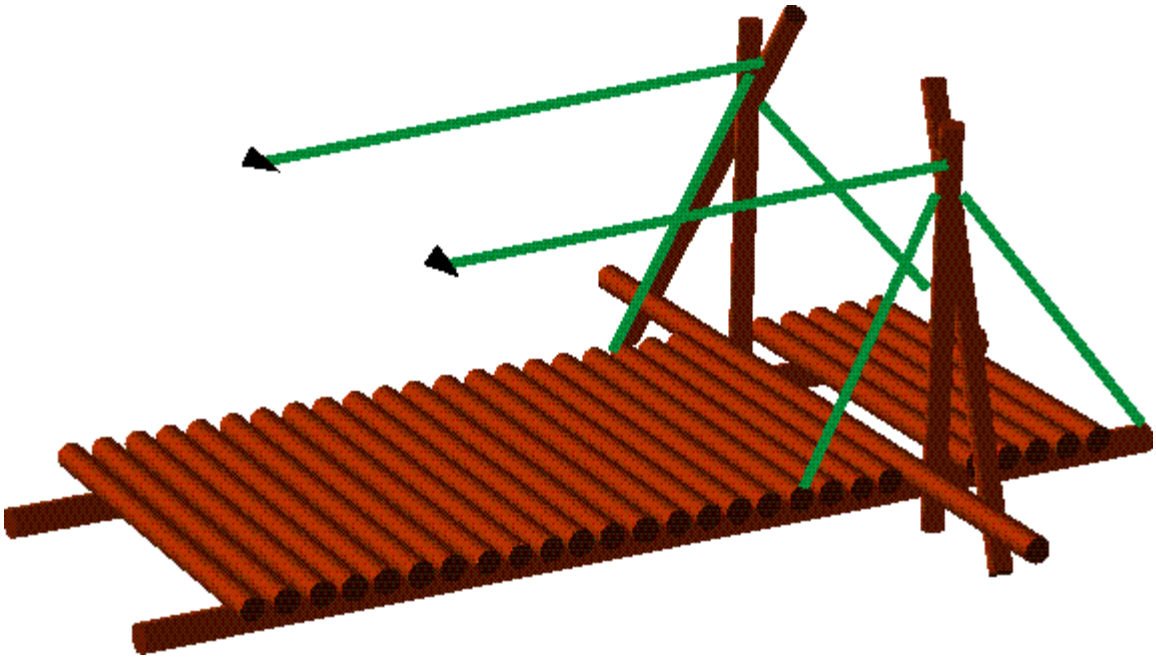
Also, you must anchor the bridge by pounding four stakes into the ground at each corner, as shown.



Would you like a handrail for your bridge? Every few feet, make one of the planks longer so that it sticks out from both sides. Remove a plank next to it. In that space put an upright spar and a diagonal spar, to form a triangle, all tied using square lashings. Do the same thing on the other side of the ramp.

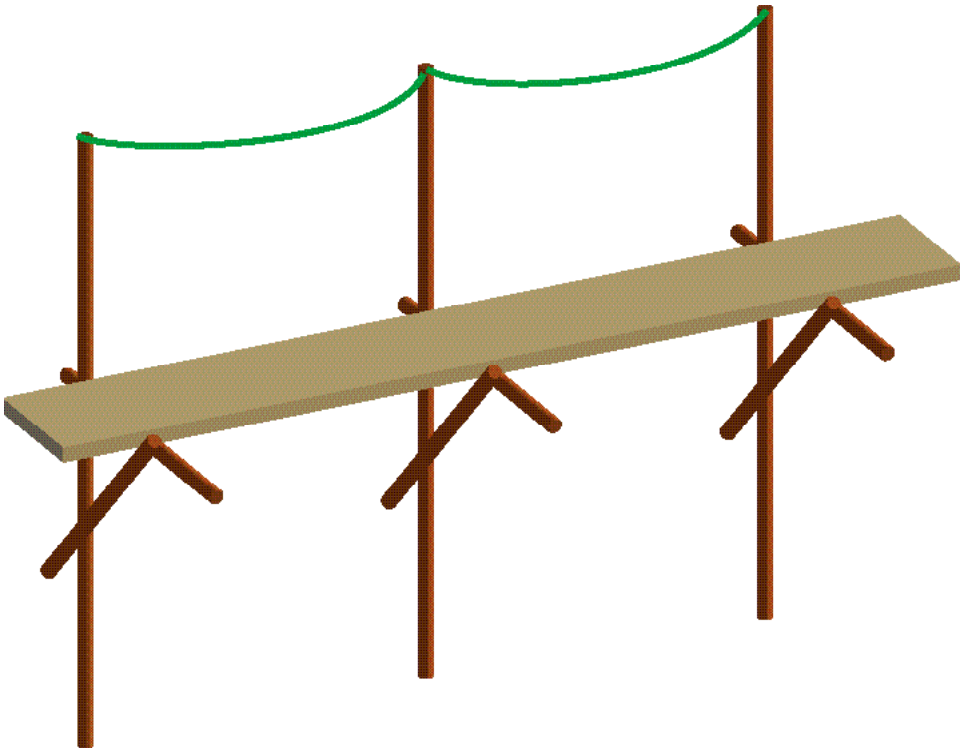
A rope on either side will help brace the upright spar.

Then string a rope all along the upright spars using clove hitches at each one. At the ends attach the "hand rail" to the ends of the long spars.



Simple Bridge

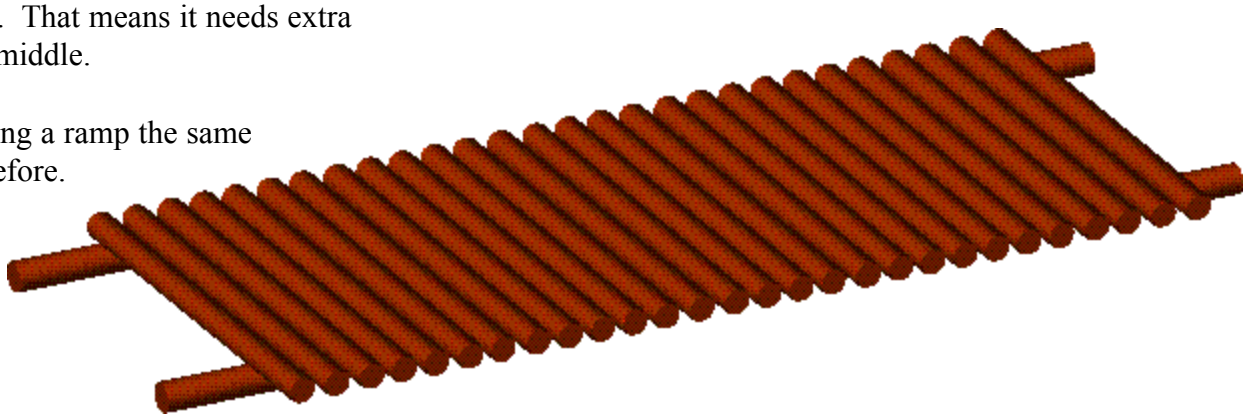
Here's another Simple Bridge, where the cross-spars are replaced by a wide board. You need to be able to pound the upright spars deep into the ground, so you can't build this bridge in deep water or on rocky stream bottoms.



Banana Bridge

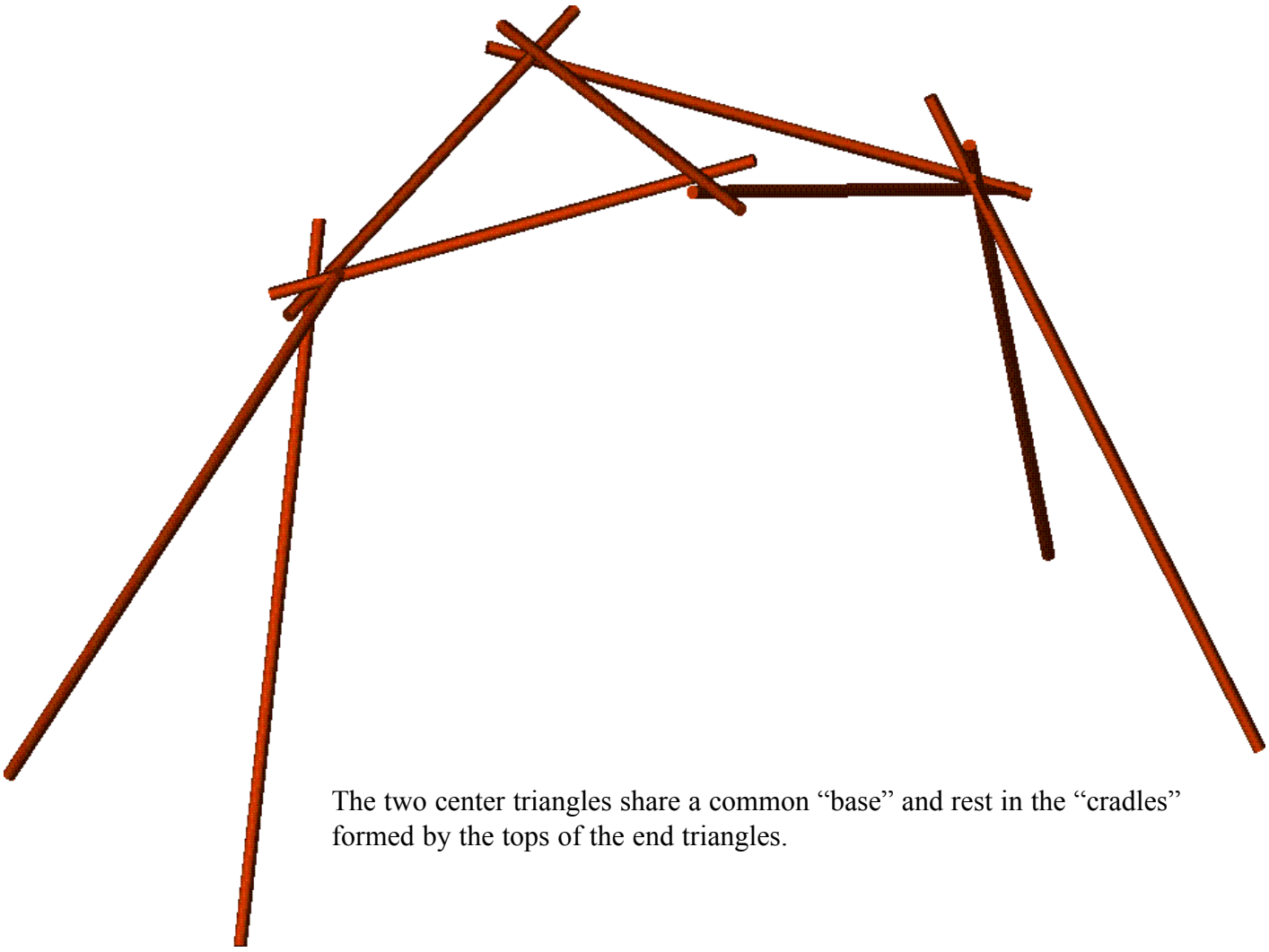
The Banana Bridge is like the first bridge, but it is longer. That means it needs extra support in the middle.

Begin by making a ramp the same way you did before.



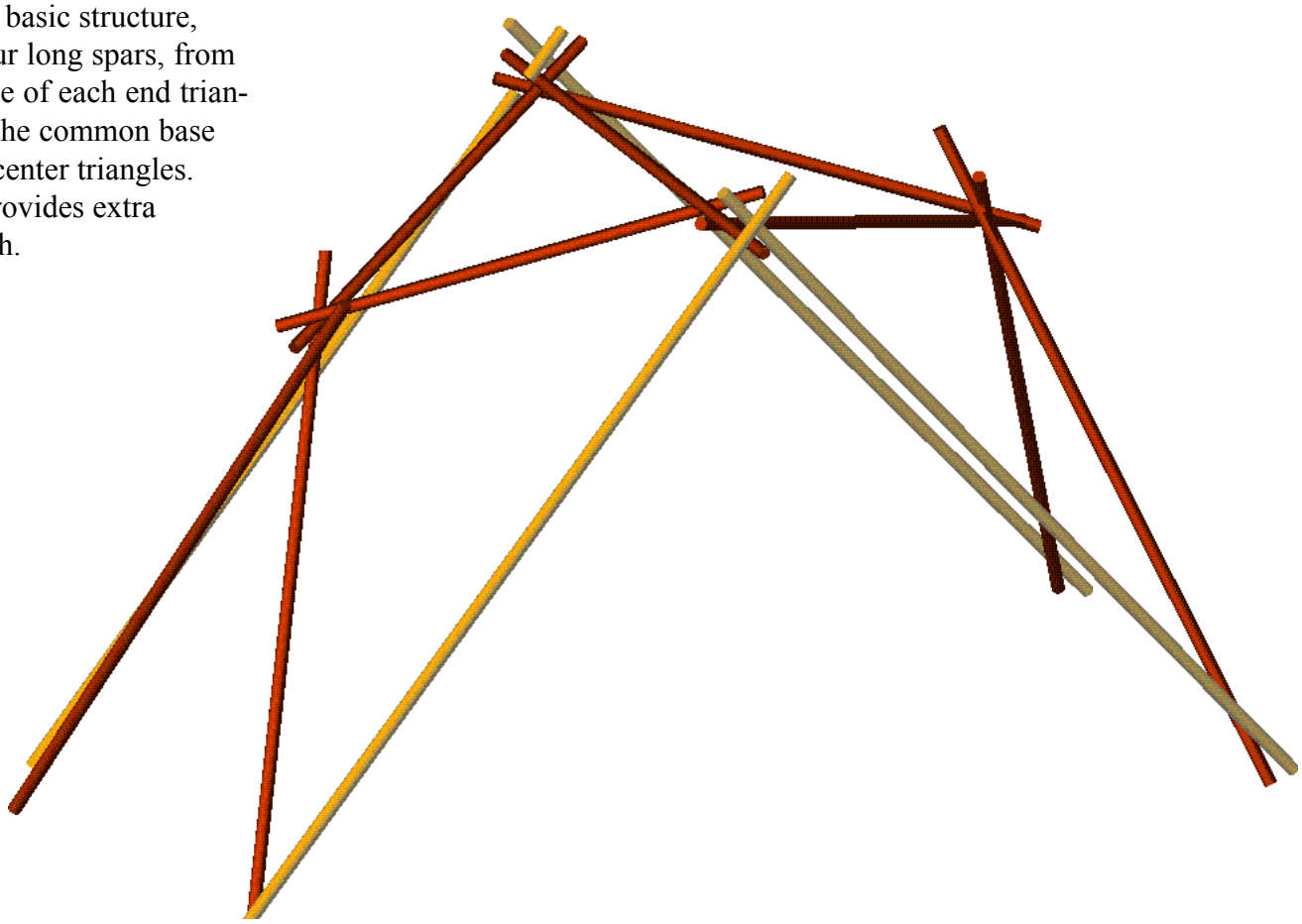
A longer bridge needs more support, either on the bottom or from the top. In the Banana Bridge, you will build a structure over the top. The center of the bridge will "hang" from that structure.

Begin by making four triangles as shown. The bottoms of the end triangles will be the spars at either end of the ramp.



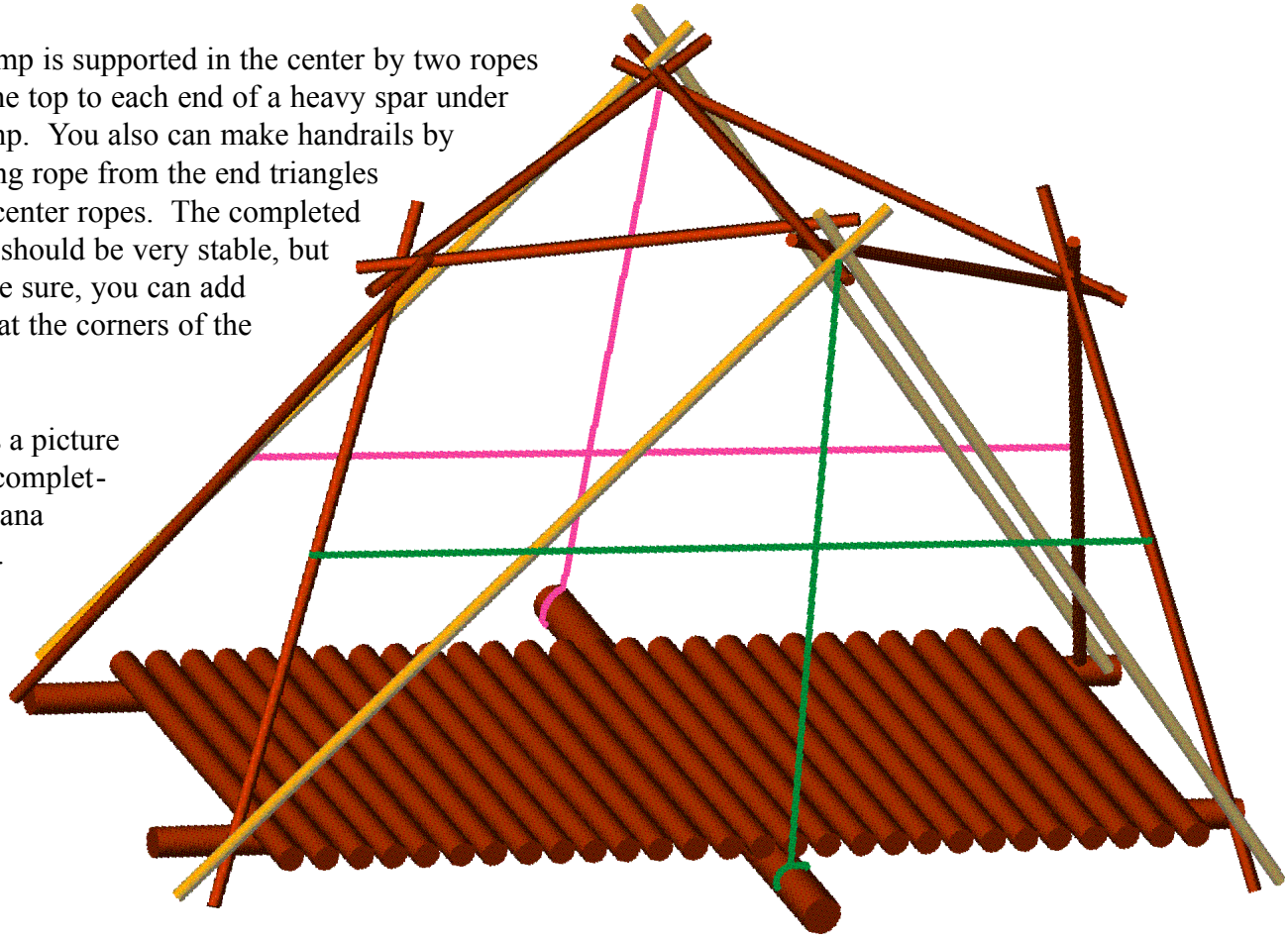
The two center triangles share a common "base" and rest in the "cradles" formed by the tops of the end triangles.

To this basic structure, add four long spars, from the base of each end triangle to the common base of the center triangles. This provides extra strength.



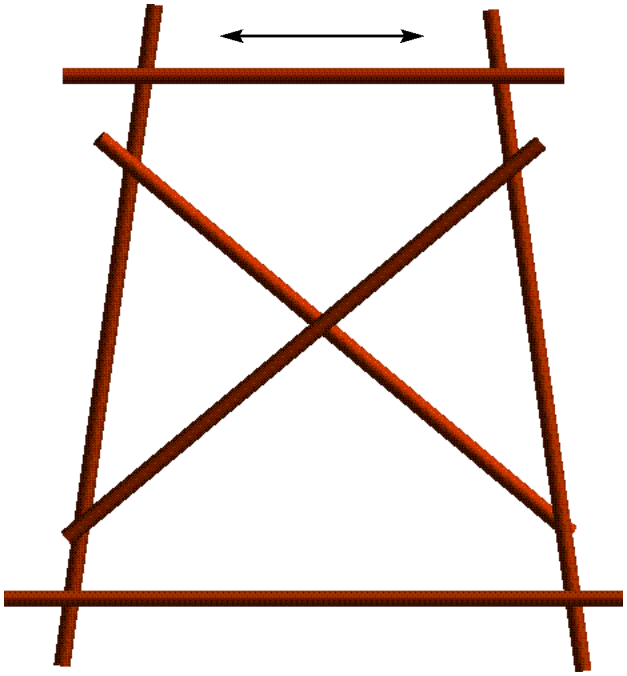
The ramp is supported in the center by two ropes from the top to each end of a heavy spar under the ramp. You also can make handrails by stringing rope from the end triangles to the center ropes. The completed bridge should be very stable, but to make sure, you can add stakes at the corners of the ramp.

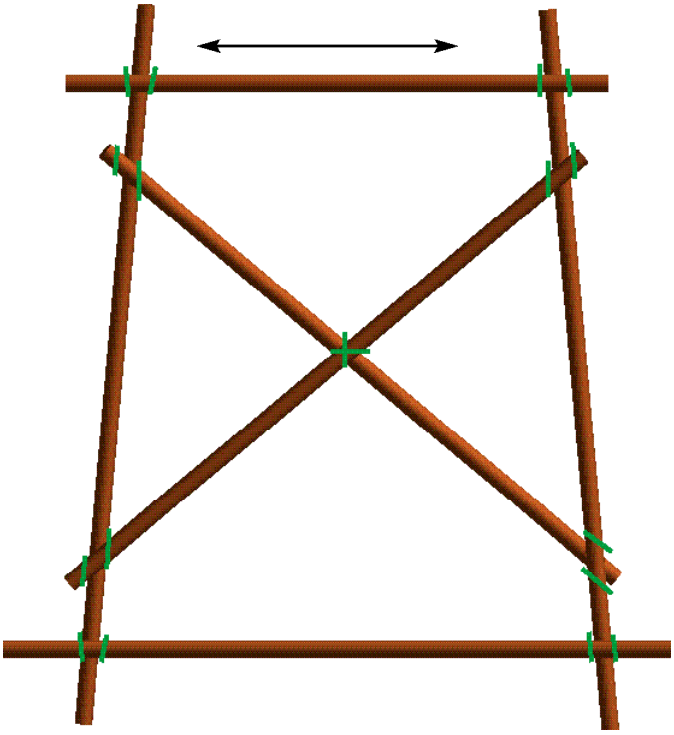
Here is a picture of the completed Banana Bridge.



Single-Lock Bridge

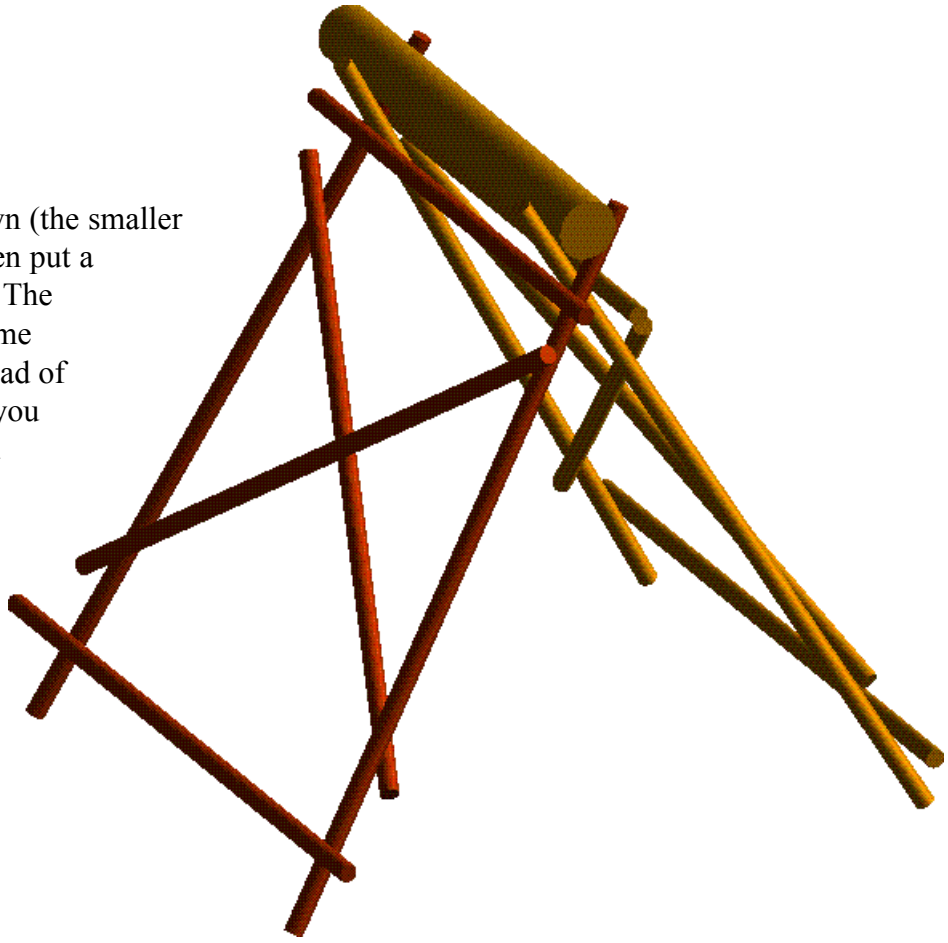
Like the Banana Bridge, the Single-Lock Bridge also can be longer than the simple bridge. This time the extra support comes from two trestles underneath two ramps.

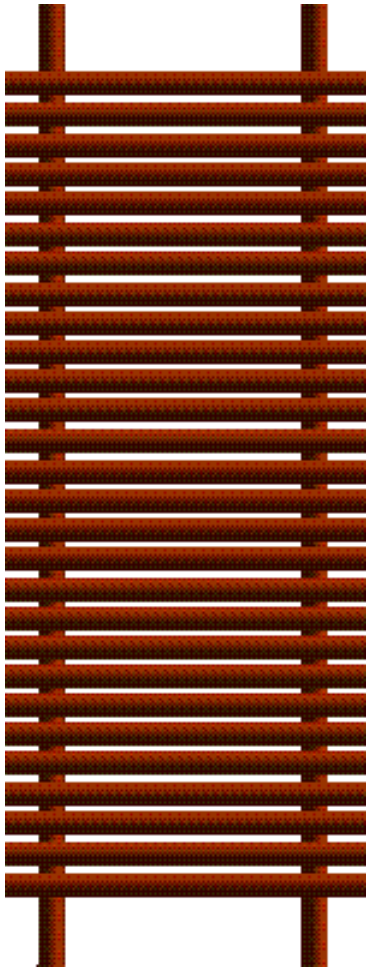




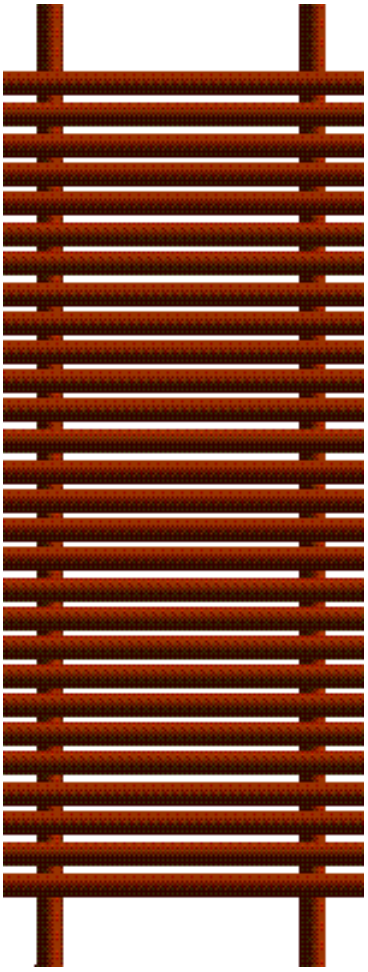
Begin by making two trestles, one wider than the other.

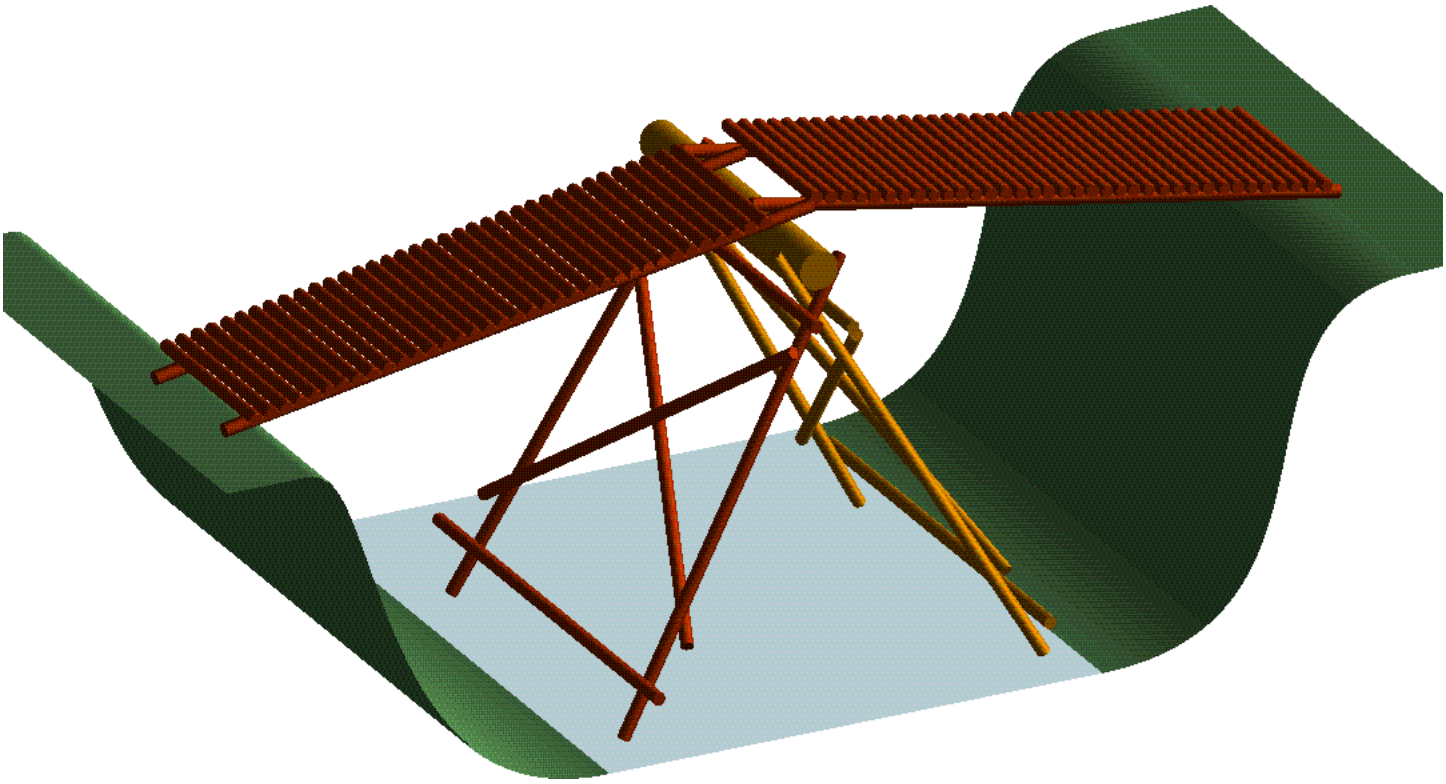
Lash the two trestles together as shown (the smaller trestle should fit inside the larger), then put a heavy spar in the "cradle" at the top. The square lashings where the trestles come together need to be very strong. Instead of making three wraps before you frap, you might want to make five to six wraps.





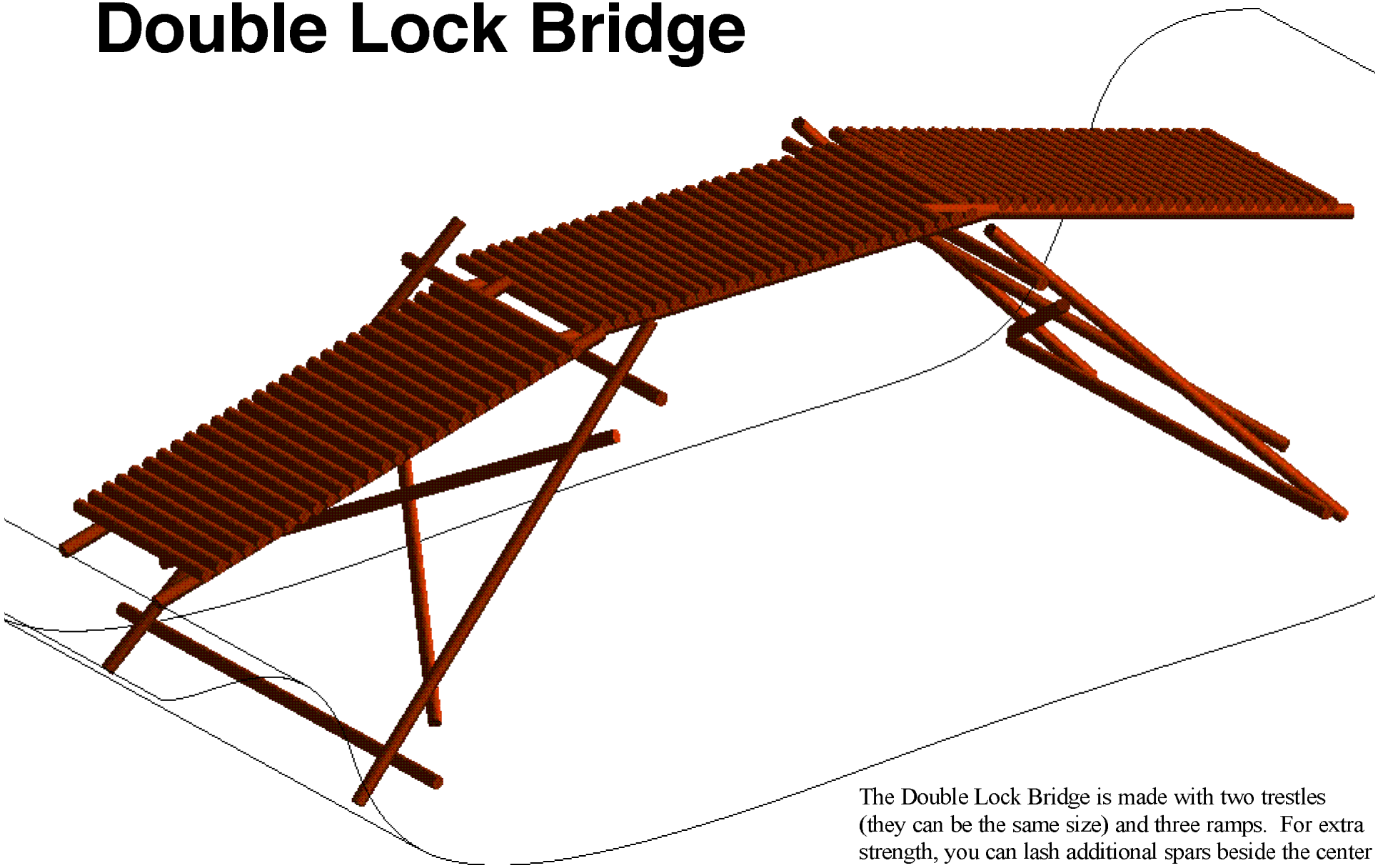
Next make two ramps, leaving extra room at the top of each to rest against the top spar.





Complete the bridge by placing the two ramps across the center spar, as shown. Lash them to each other and to the center spar. Dig small holes to hold the ends of the ramps in place or use stakes. If you want to add handrails, look at the drawing earlier in the chapter and change it a little to fit the ramps.

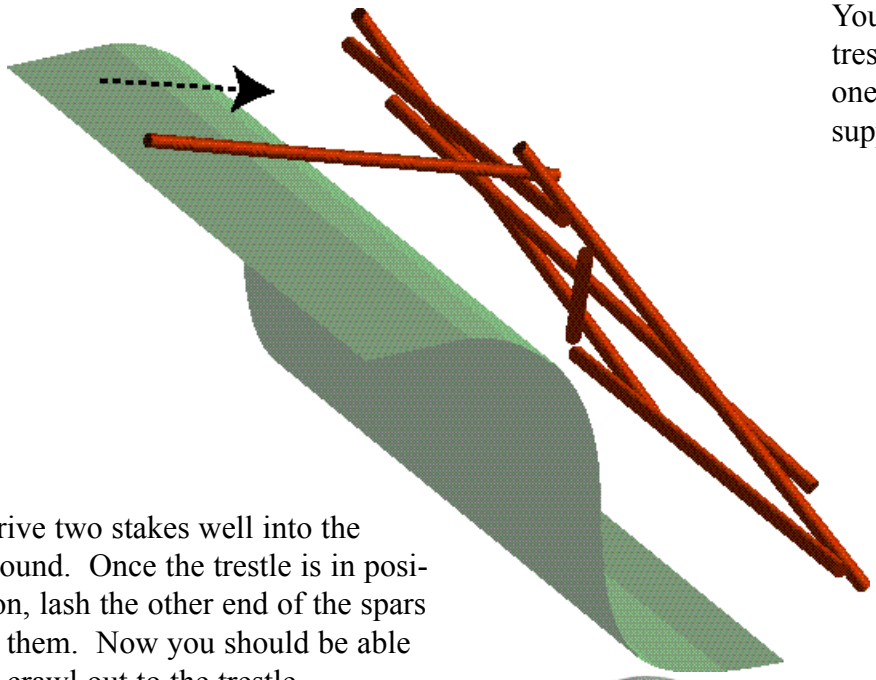
Double Lock Bridge



The Double Lock Bridge is made with two trestles (they can be the same size) and three ramps. For extra strength, you can lash additional spars beside the center ramp. Be sure to lash all three ramps tightly to the transoms of the trestles.

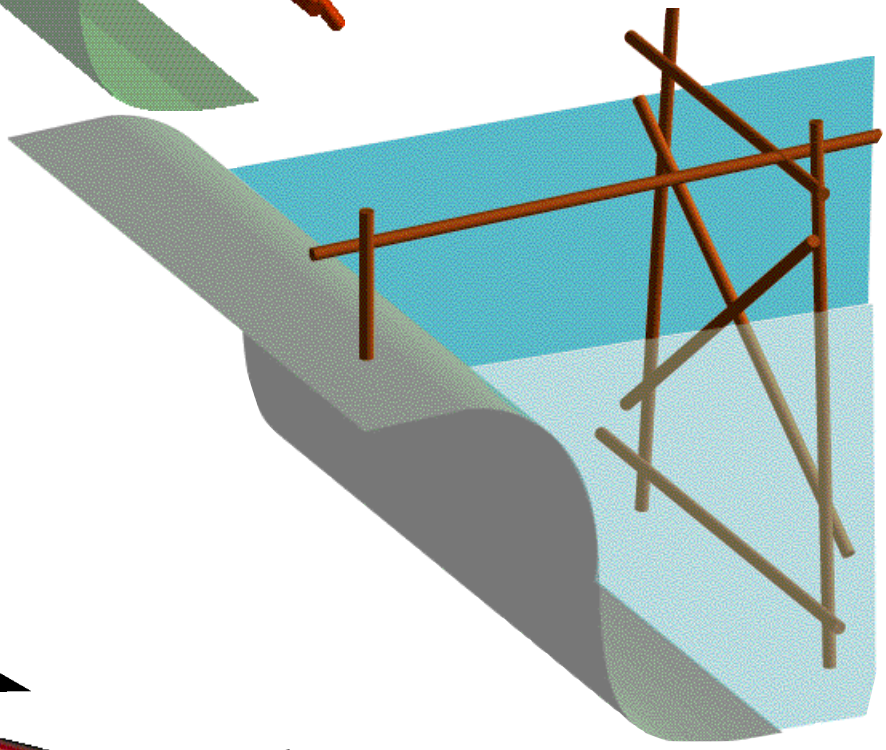
You might be wondering how to get your trestles into the middle of the river. Here's one way. It can be used for placing any support in a stream.

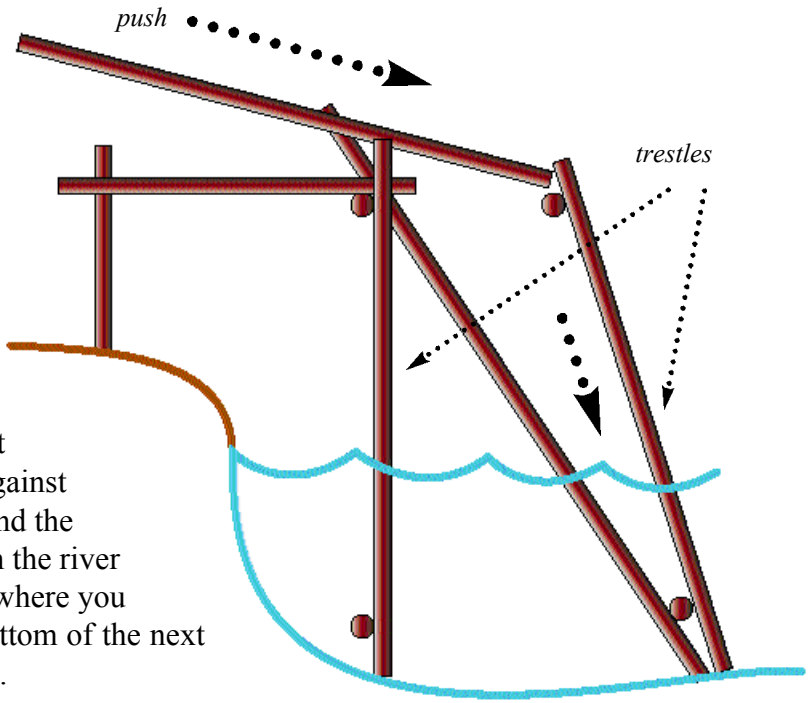
Begin by sliding the first trestle down the bank. Lash two spars to the top and use them to push the trestle upright. (Only one spar is shown.)



Drive two stakes well into the ground. Once the trestle is in position, lash the other end of the spars to them. Now you should be able to crawl out to the trestle.

(If you are building the Single or Double-Lock Bridges, just push the top of the trestle further out until it slants forward.)

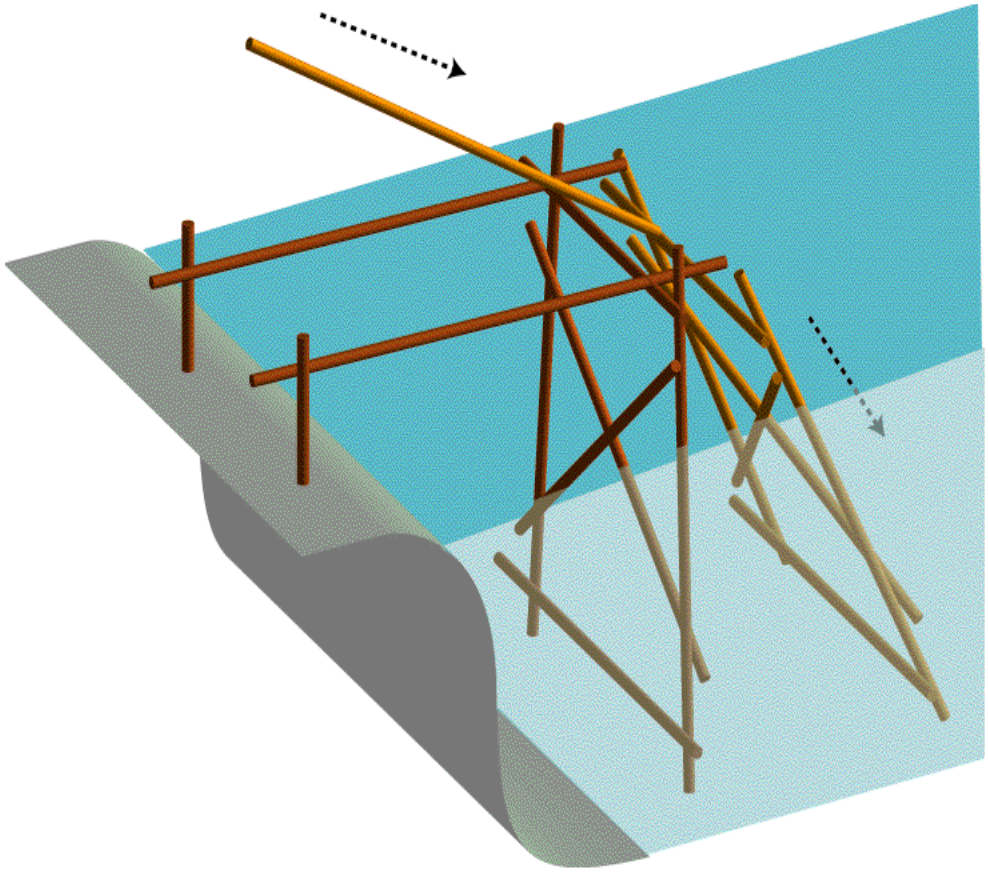




Take one or two spars out to the trestle. Rest the top(s) against the trestle and the bottom(s) in the river just before where you want the bottom of the next trestle to go.

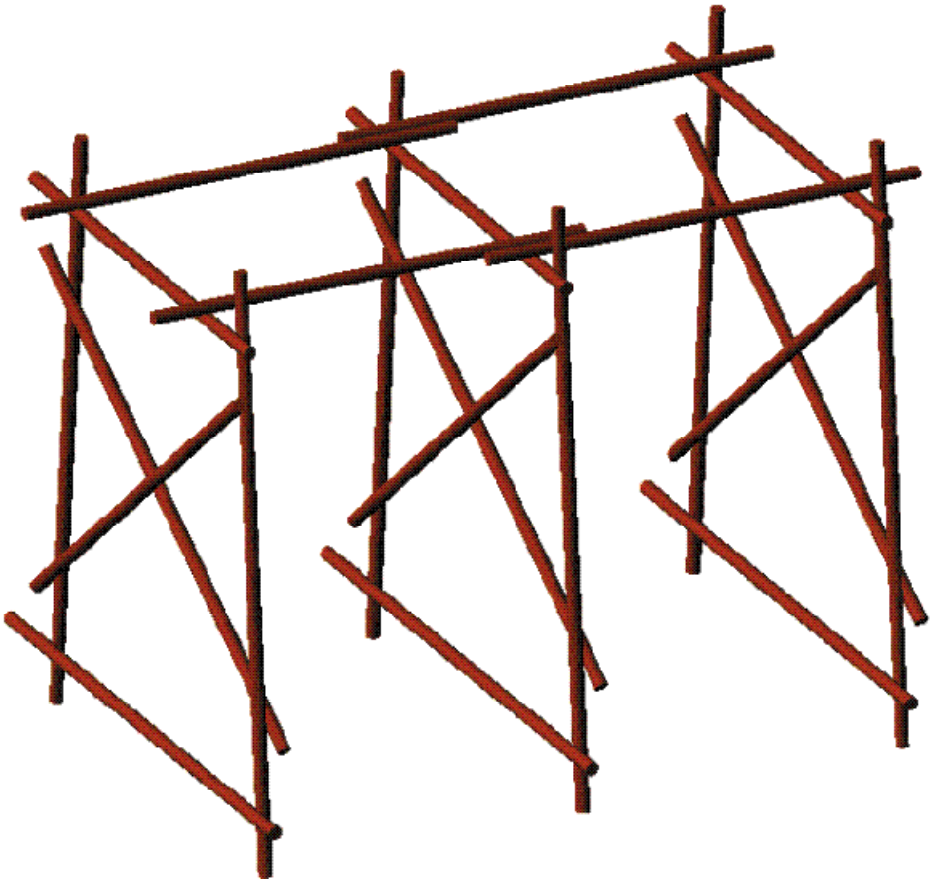
Tie two spars to the top of the second trestle. Slide the trestle down the spars until it rests on the river bottom. Then use the spars to push it upright and finish off by lashing the spars to the first trestle.

(If you are building the Single-Lock Bridge, you won't need to push the top of the second trestle upright. Just lash it to the first trestle as shown on the previous page.)

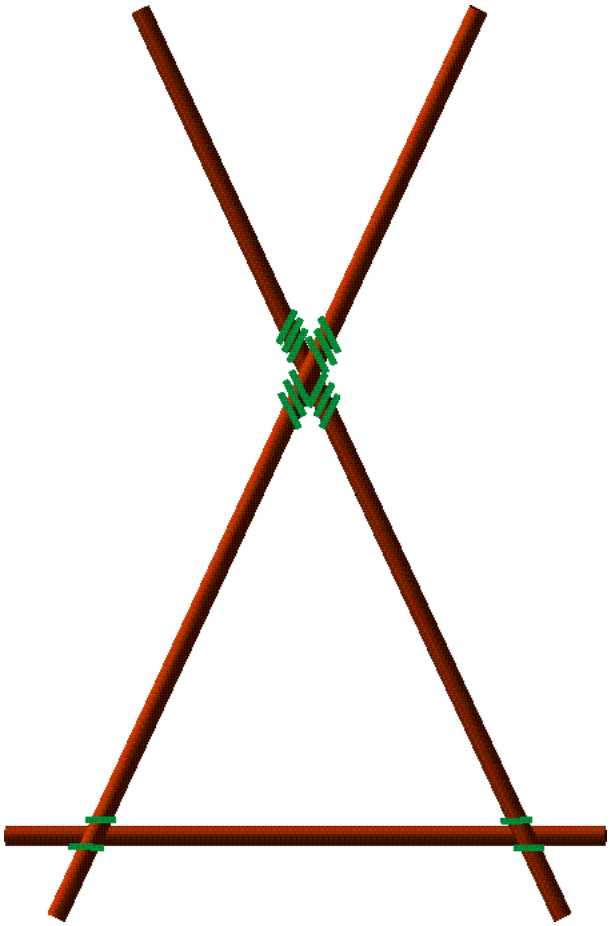


Here is how it looks without the “slide.” From this point, you push the top of the second trestle outward until it is upright. Then lash your “push rods” to the first trestle. That will brace it.

There is no limit to the number of times you can do this. You can build a bridge across a very wide stream. Just keep adding trestles in the same way. To make the process easier, each time you complete a section, add the cross-spars to make your walkway.



X-Bridge

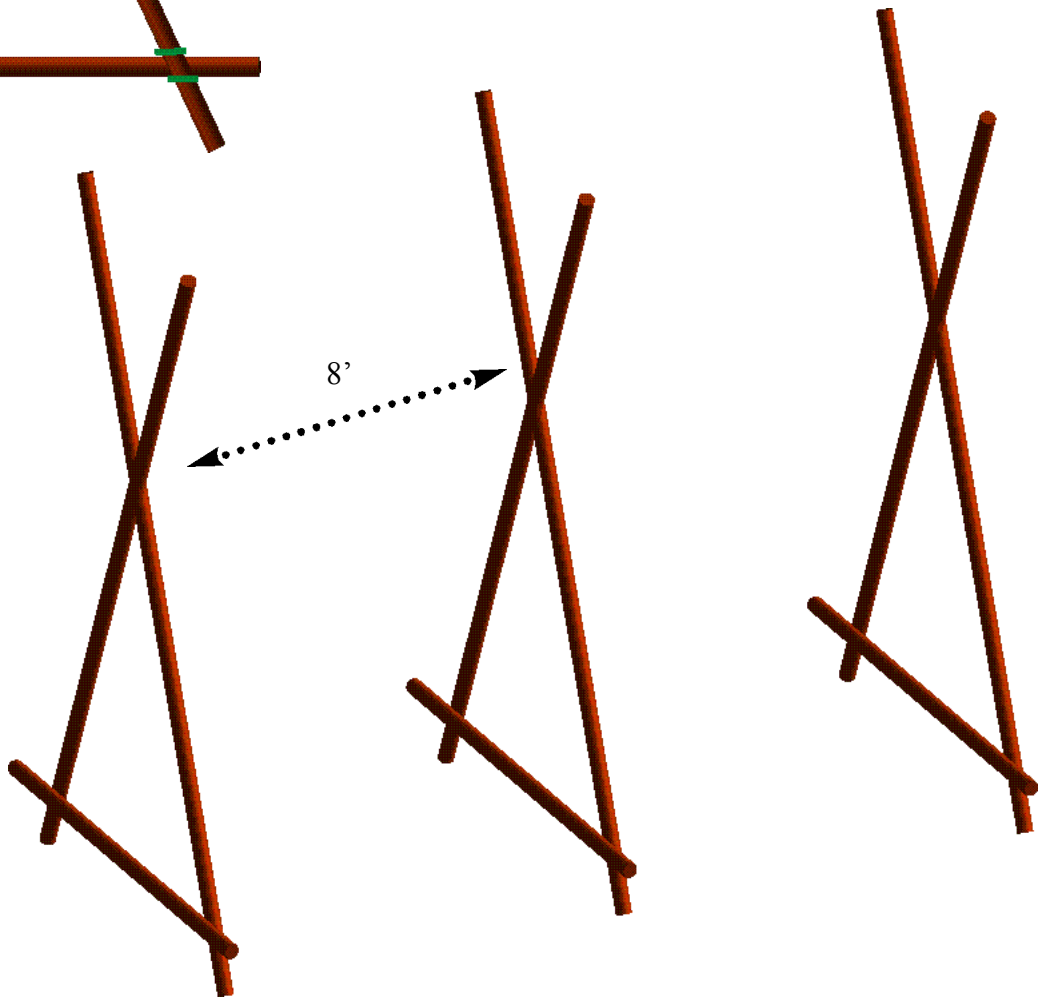


The X-Bridge can be as long as you like. All you have to do is add more sections.

The basic part is a triangle with two of its sides lashed in the middle rather than at the ends.

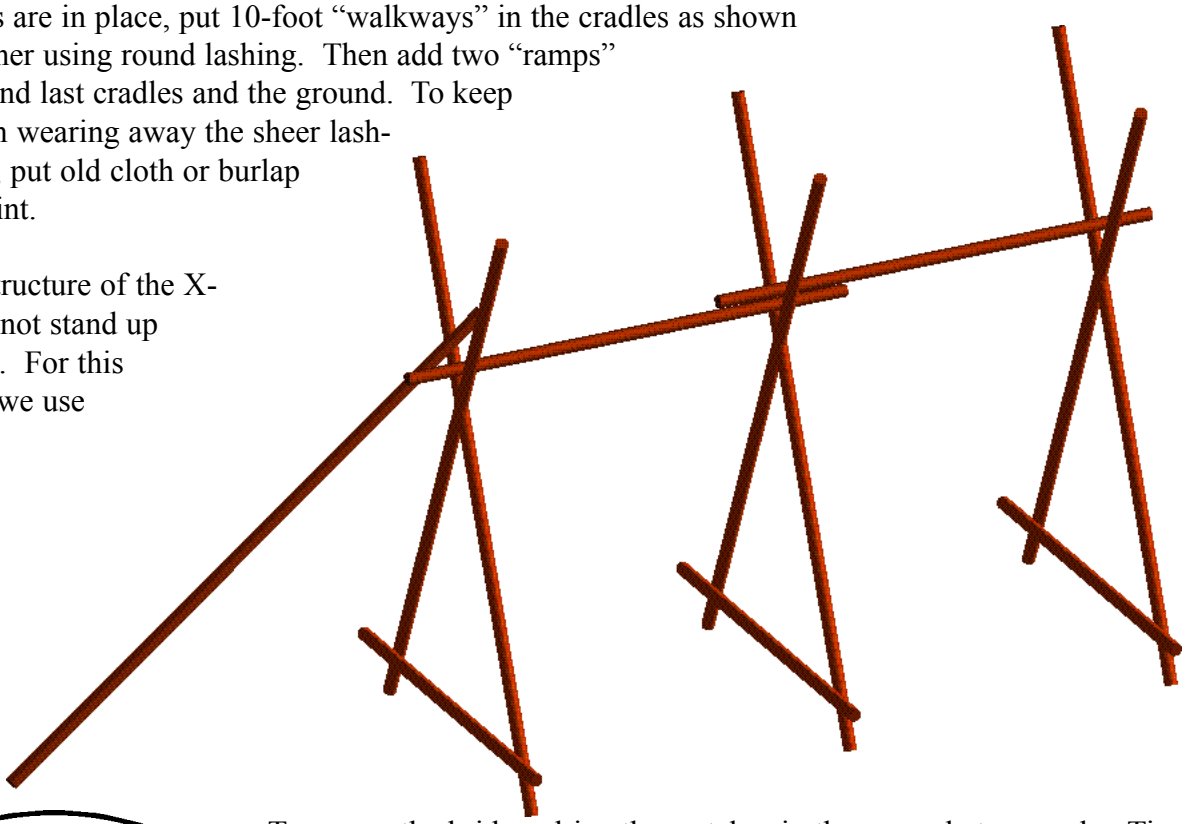
At the bottom use the normal square lashings, but in the middle, tie a sheer lashing. The cross-piece should be five feet, and the two long pieces should be twelve feet each. The sheer lashing is five feet from the top and the cross-piece is two feet from the bottom.

You will build enough of these triangles so that they will be no more than eight feet apart when the bridge is complete.

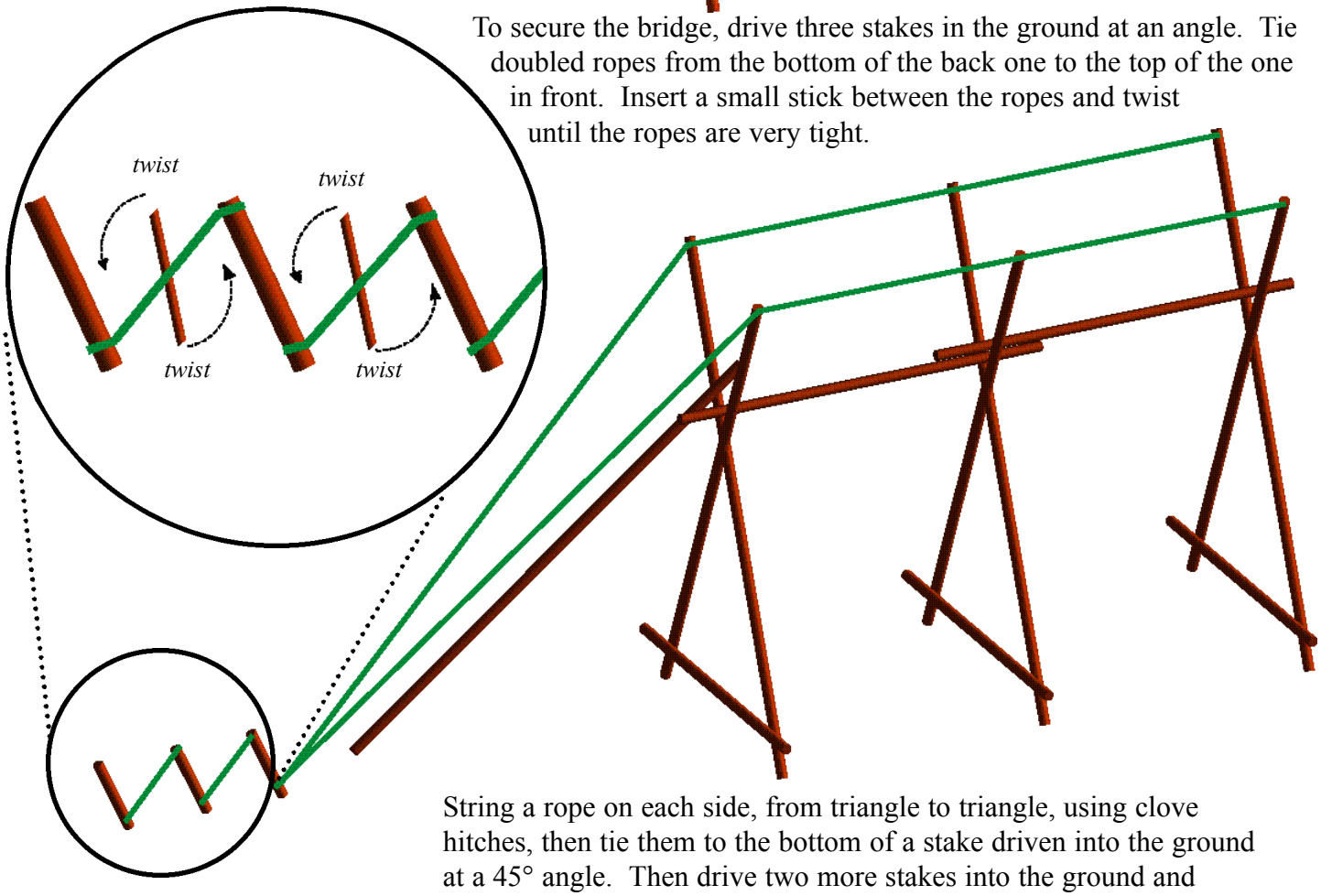


When the triangles are in place, put 10-foot "walkways" in the cradles as shown and tie them together using round lashing. Then add two "ramps" between the first and last cradles and the ground. To keep the walkways from wearing away the sheer lashings at the cradles, put old cloth or burlap padding at each joint.

This is the basic structure of the X-Bridge, but it will not stand up without some help. For this and for handrails, we use more rope.



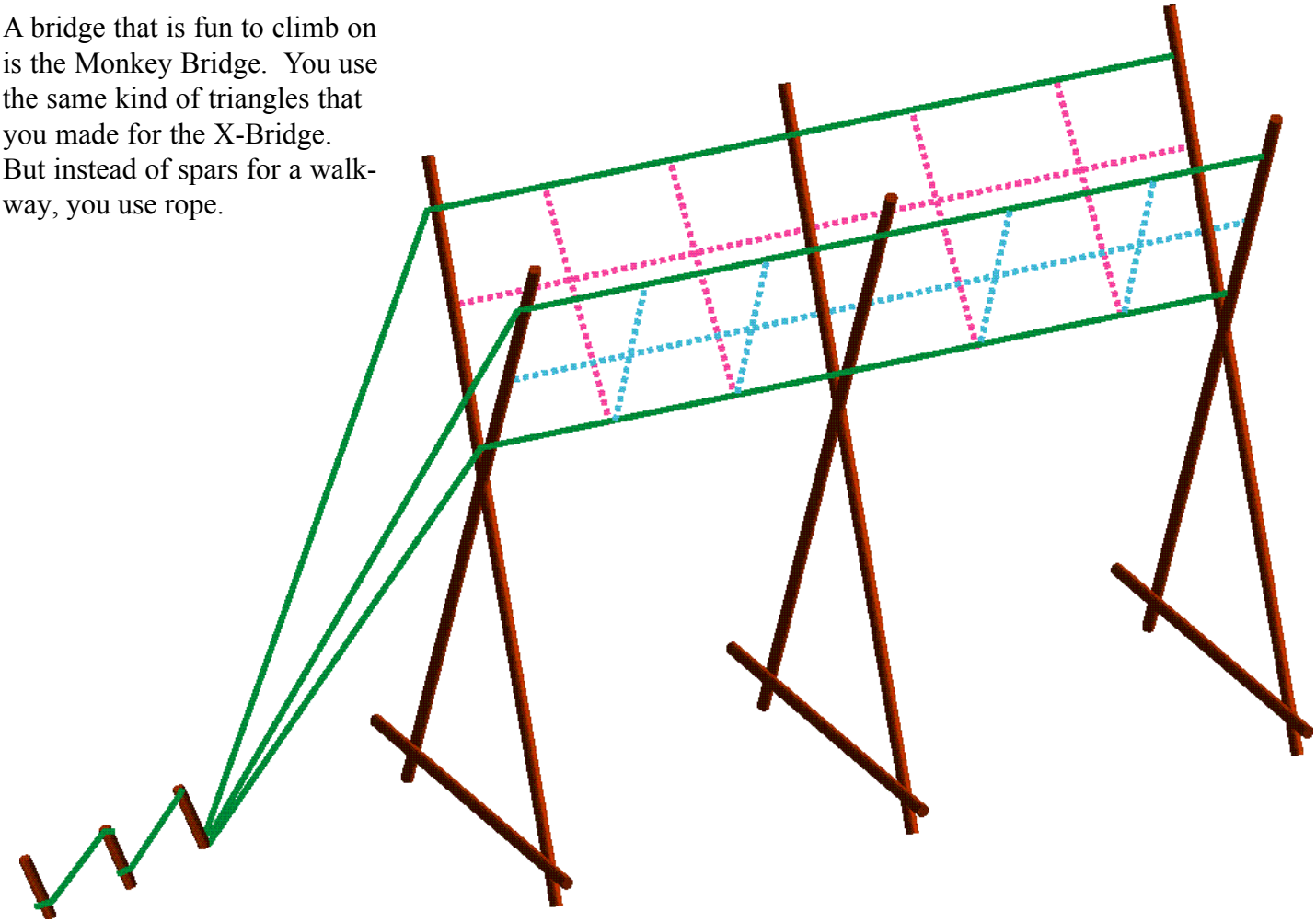
To secure the bridge, drive three stakes in the ground at an angle. Tie doubled ropes from the bottom of the back one to the top of the one in front. Insert a small stick between the ropes and twist until the ropes are very tight.



String a rope on each side, from triangle to triangle, using clove hitches, then tie them to the bottom of a stake driven into the ground at a 45° angle. Then drive two more stakes into the ground and attach more ropes as shown in the blow-up. The ropes act as handrails and also make the bridge stable.

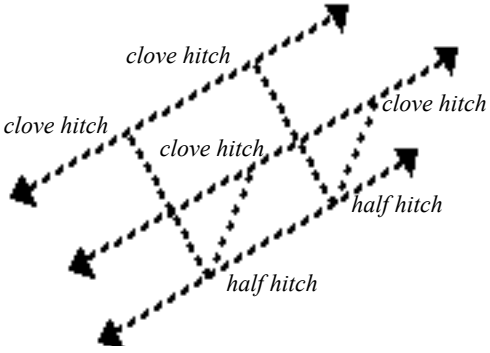
Monkey Bridge

A bridge that is fun to climb on is the Monkey Bridge. You use the same kind of triangles that you made for the X-Bridge. But instead of spars for a walk-way, you use rope.



As before the handrails are tied to the sides of the triangles with clove hitches, but in place of a walkway, you use heavy rope. The short pieces of rope that go from the handrails to the foot rope are called "stringers." They are made out of single pieces of rope tied to the handrails with clove hitches and tied around the foot rope with a half hitch (really, a single wrap around the foot rope). The foot rope also replaces the runway, and it is tied to the first stake. As with the X-Bridge, you need to put cloth or burlap wherever the foot rope crosses a cradle to keep it from wearing.

In addition, you need to be careful a about your rope and knots. Anytime rope is going to be under a strain, check to make sure it is not frayed and that it is big enough to hold the weight. All knots make ropes weaker, so remember that when you are thinking about how heavy your rope needs to be.



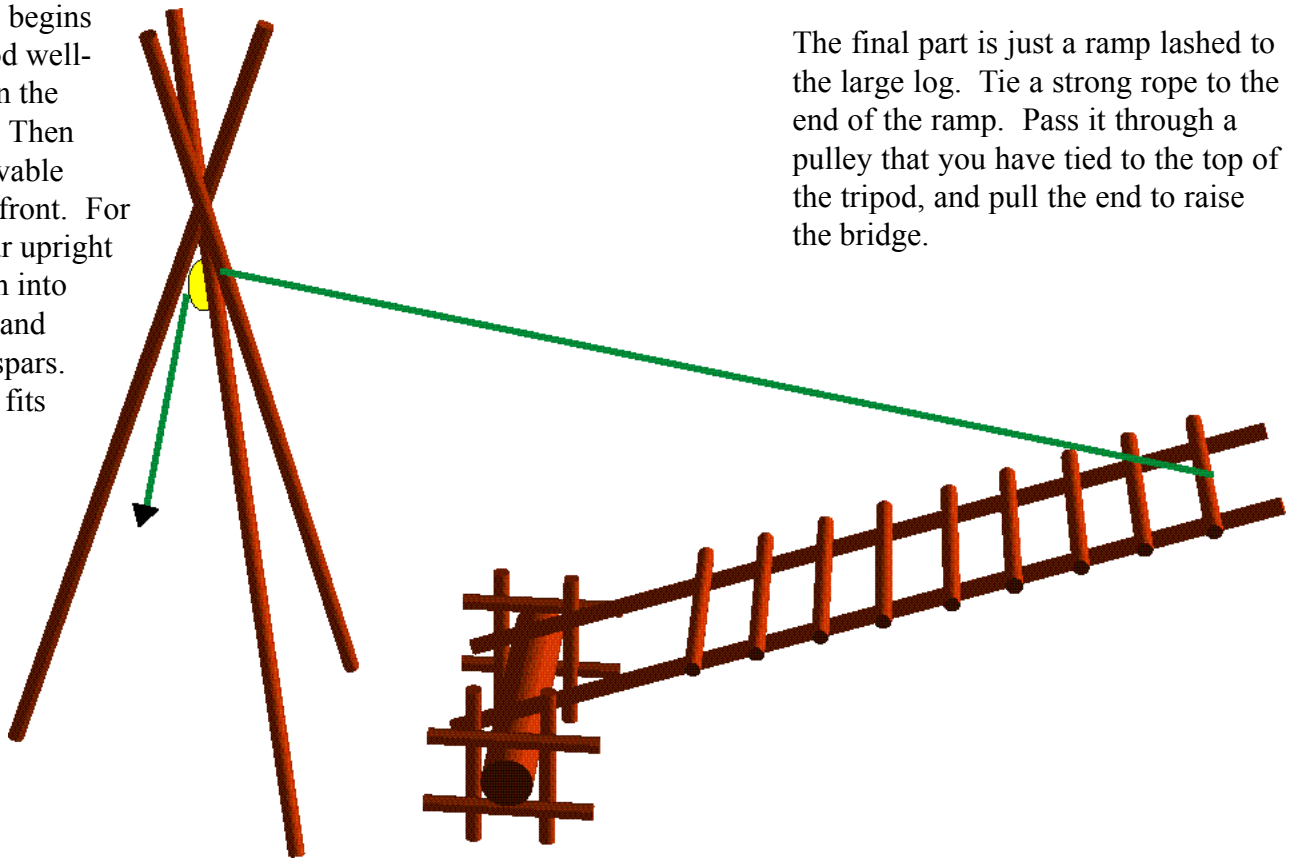
In any case, be sure to check all your ropes and knots each time you are finished using the bridge.

The Monkey Bridge is a lot of fun. It's hard to walk on the rope and keep your balance. The further apart the triangles are, the more the rope will sway back and forth.

Hint: The foot rope does not need to be very far off the ground.

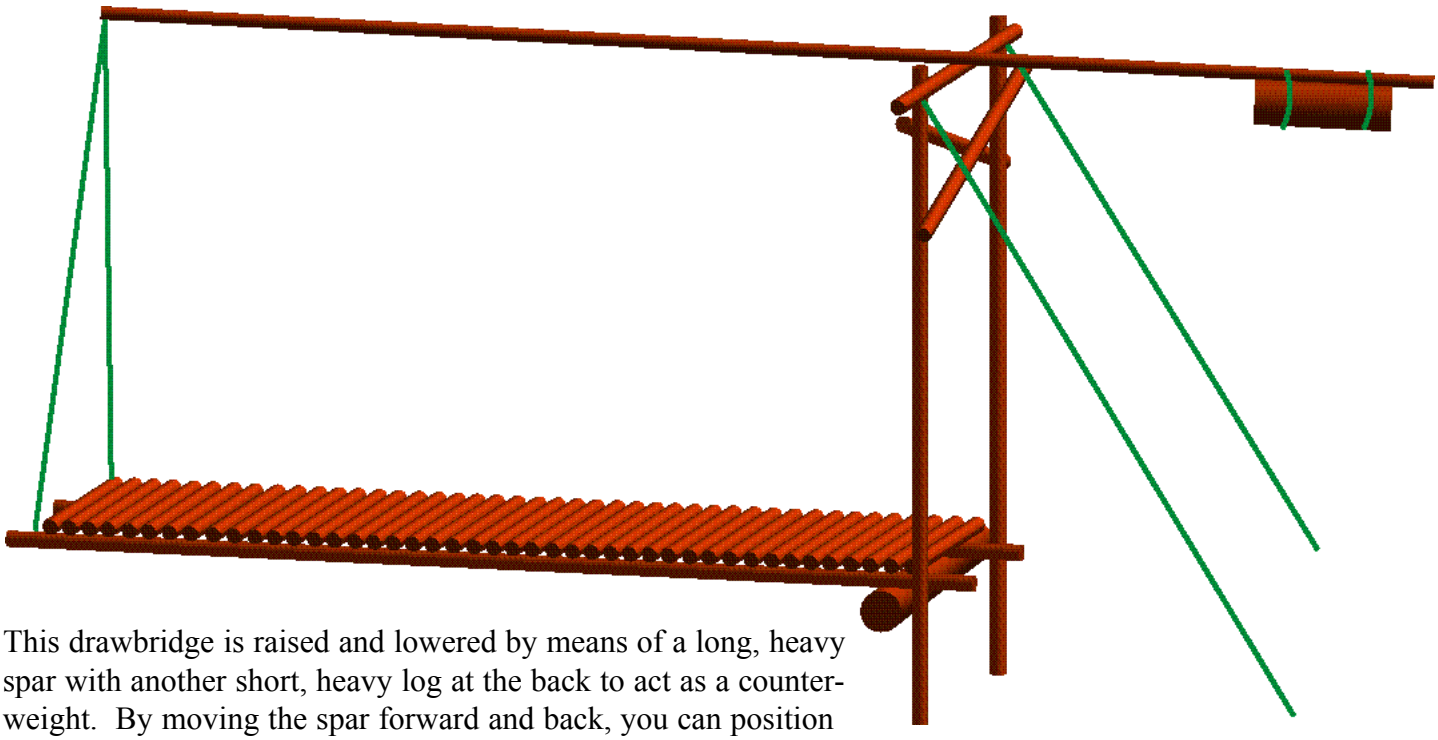
Gilwell Draw Bridge

This bridge begins with a tripod well-anchored on the river bank. Then build a Movable Bearing in front. For this use four upright spars driven into the ground and four cross-spars. A large log fits across as shown, and is not lashed down.



The final part is just a ramp lashed to the large log. Tie a strong rope to the end of the ramp. Pass it through a pulley that you have tied to the top of the tripod, and pull the end to raise the bridge.

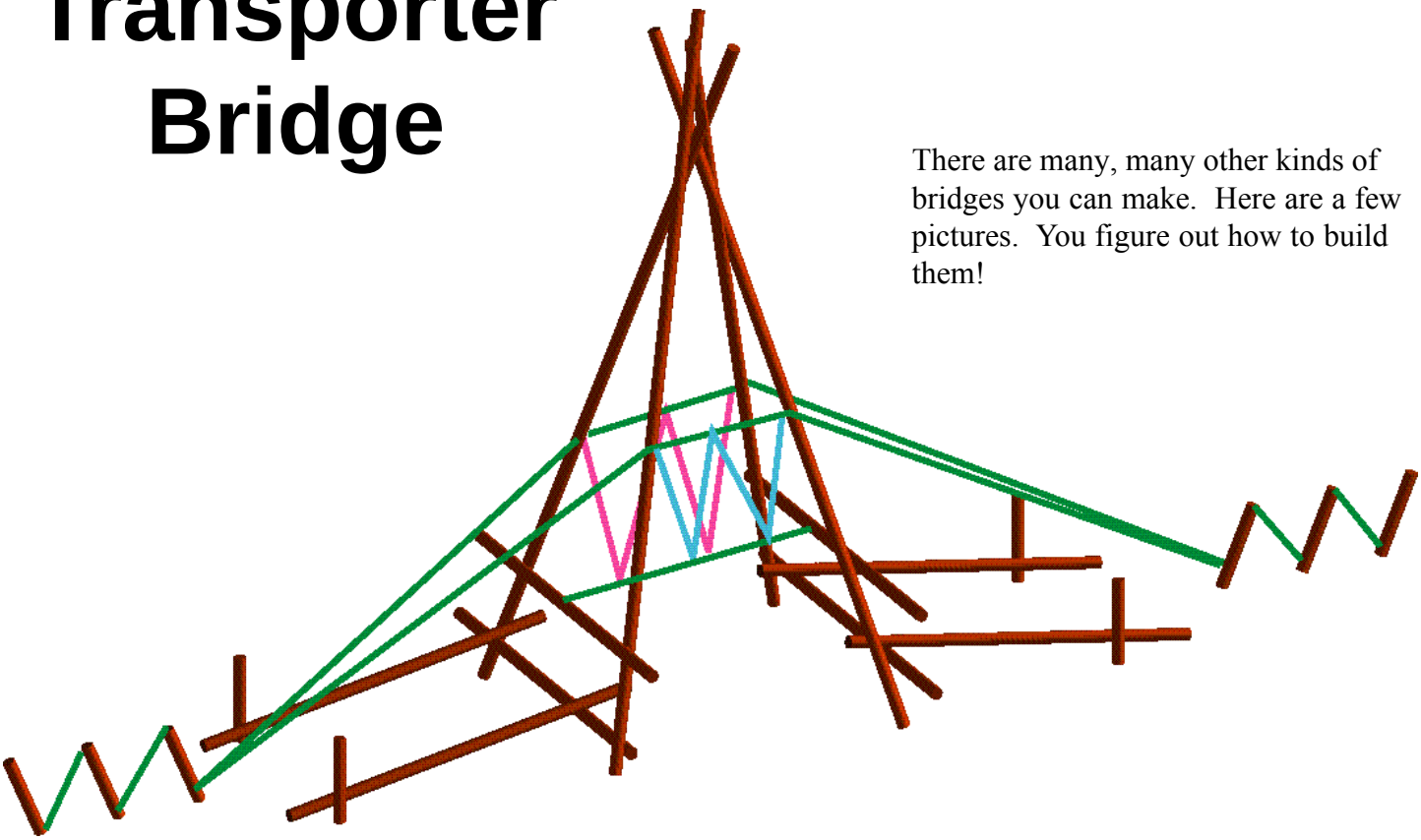
Counterweight Drawbridge

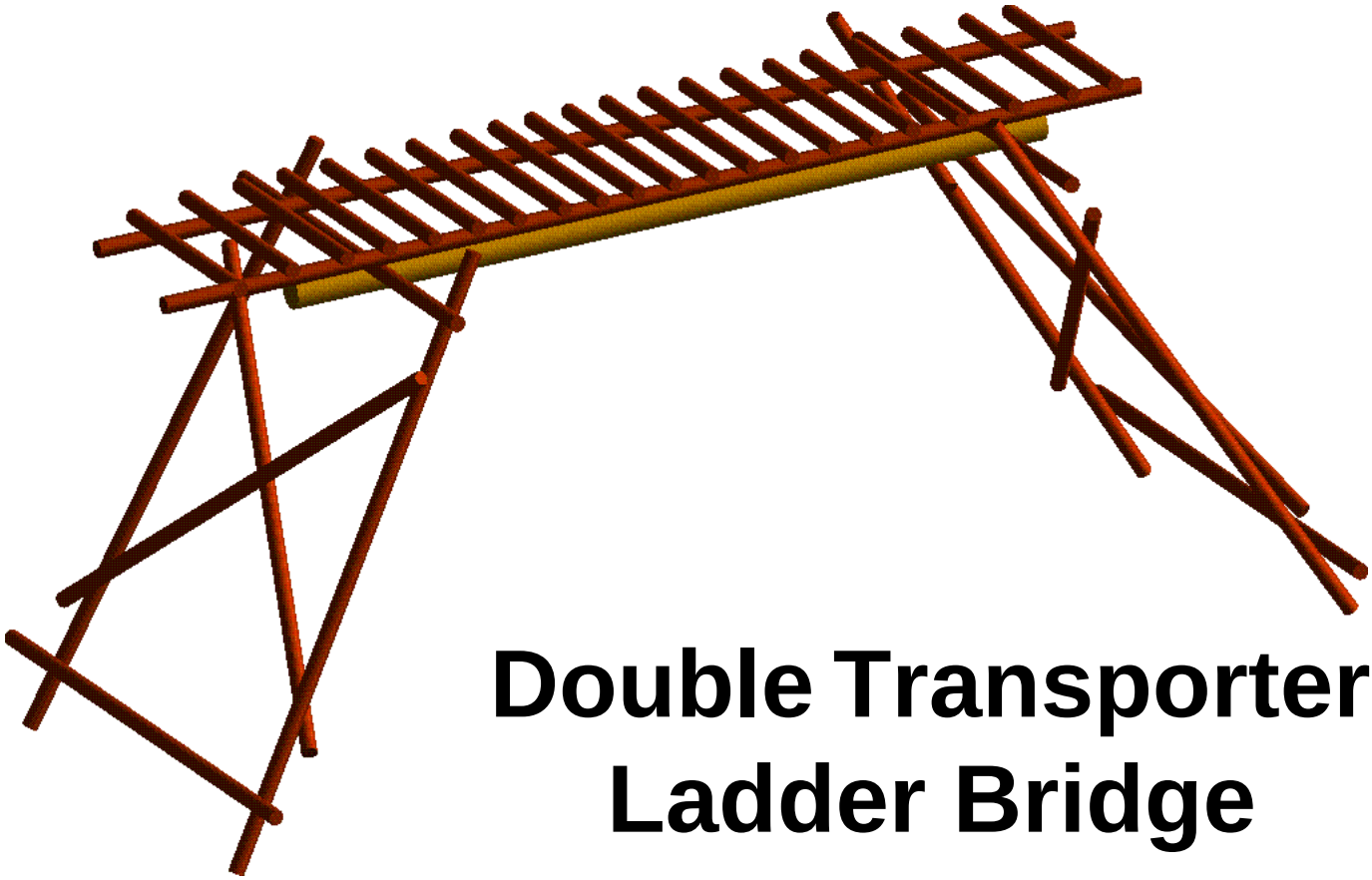


This drawbridge is raised and lowered by means of a long, heavy spar with another short, heavy log at the back to act as a counter-weight. By moving the spar forward and back, you can position it so that the bridge moves up and down easily.

Transporter Bridge

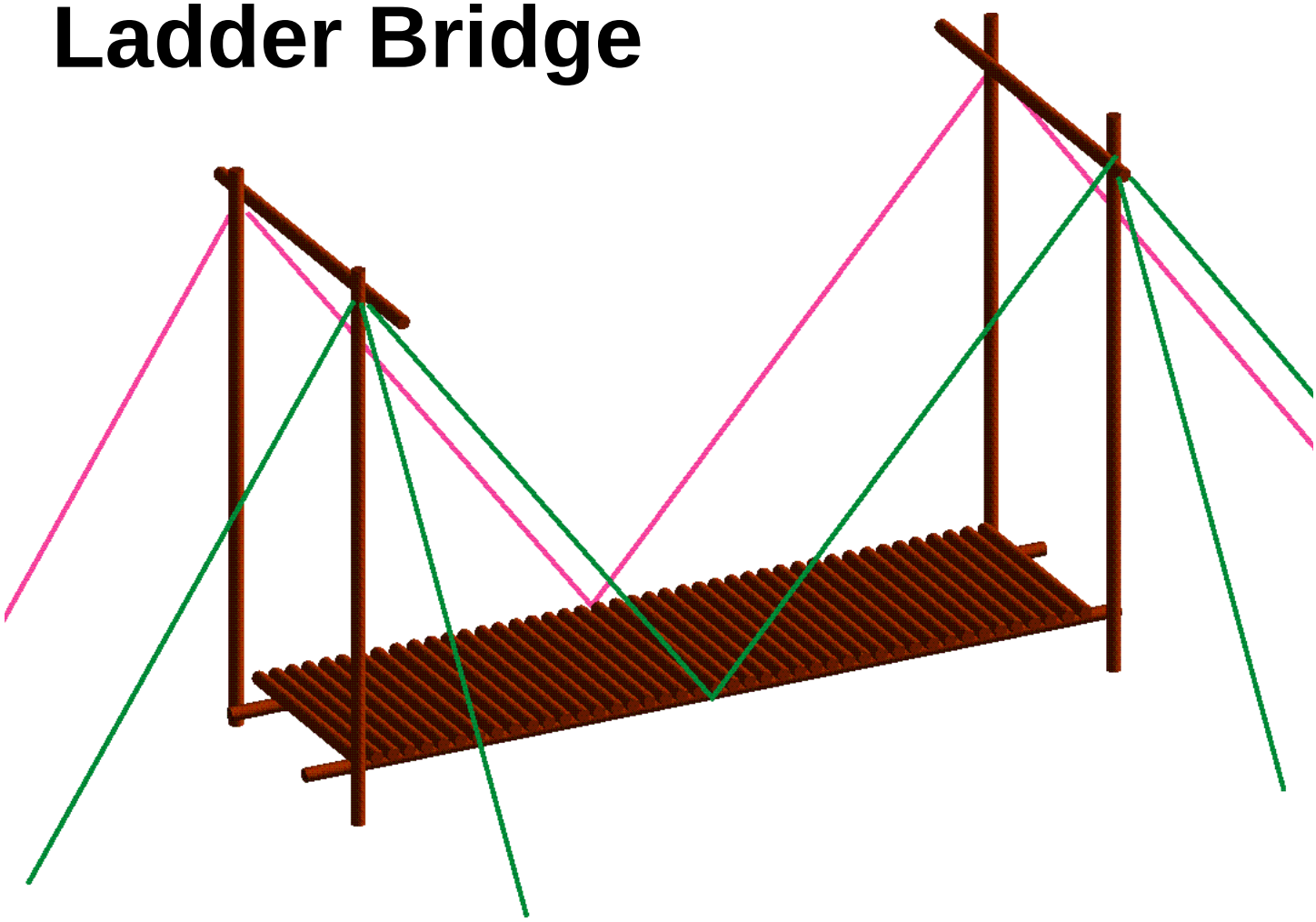
There are many, many other kinds of bridges you can make. Here are a few pictures. You figure out how to build them!



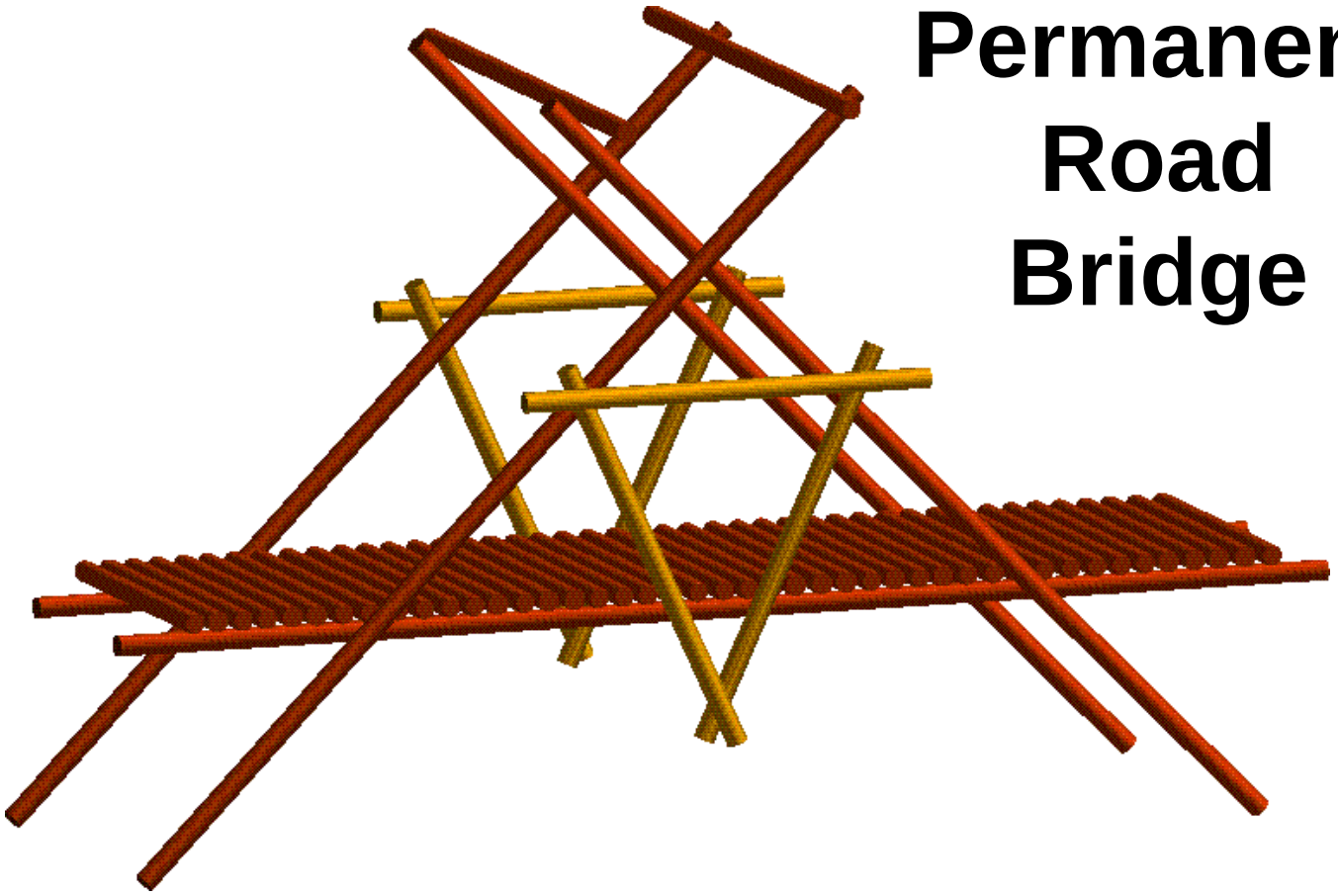


Double Transporter Ladder Bridge

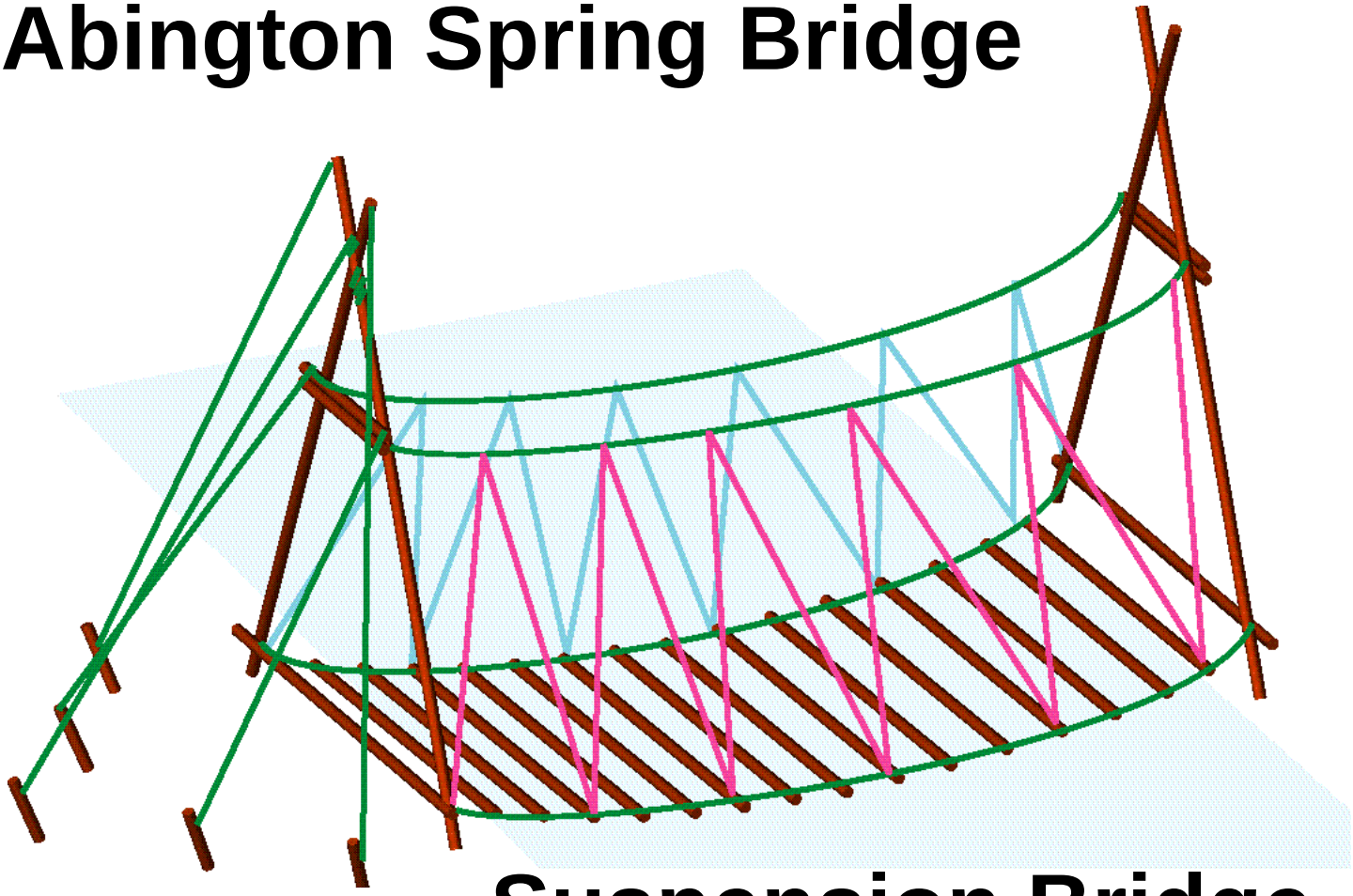
Ladder Bridge



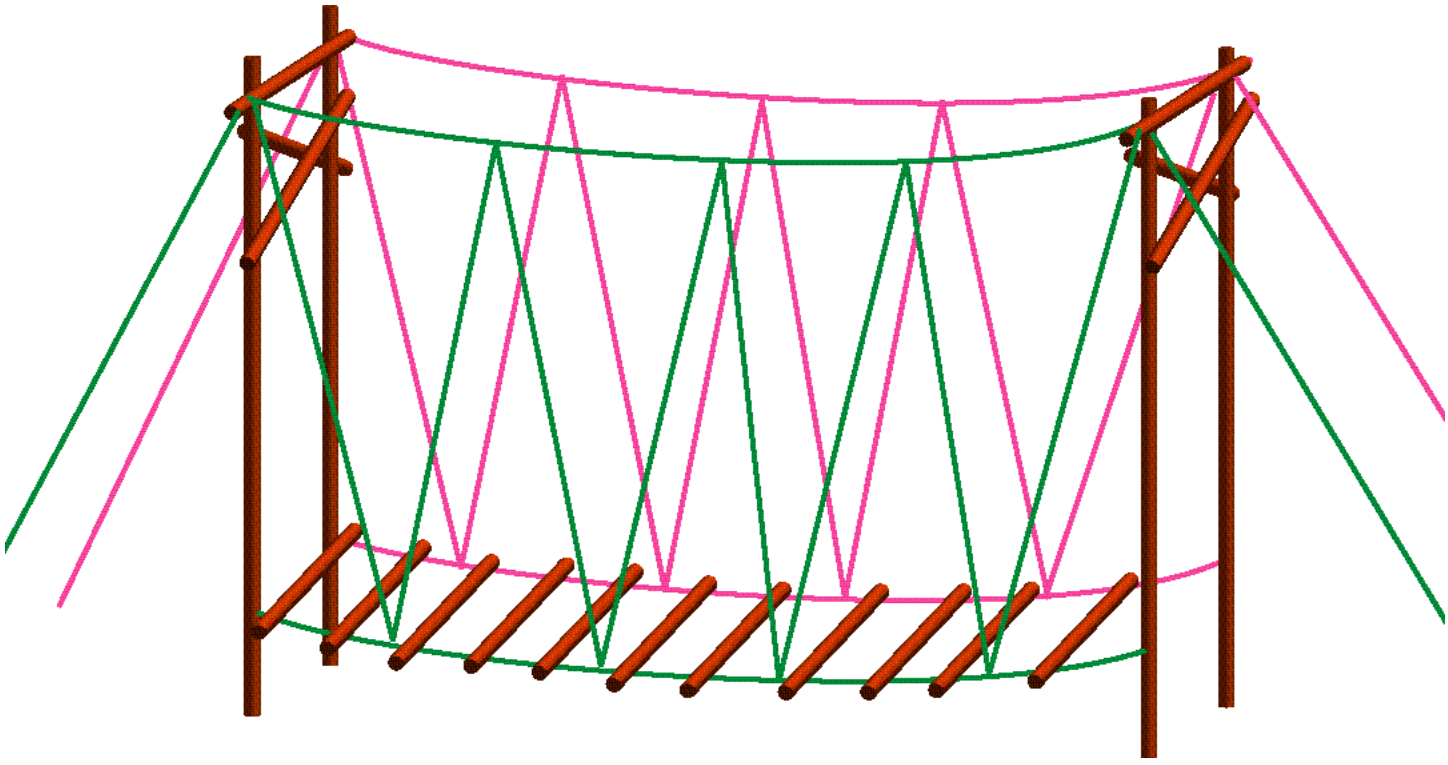
Permanent Road Bridge



Abington Spring Bridge



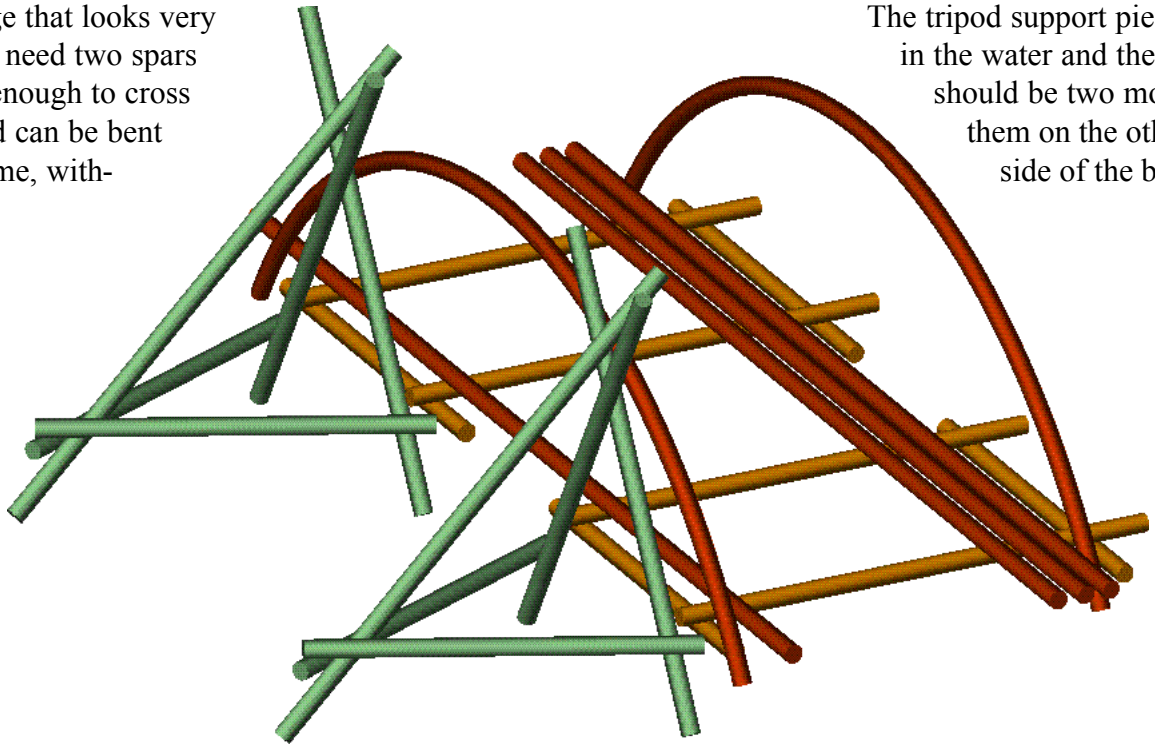
Suspension Bridge



To lash the walkway, see how to make a rope ladder in Chapter IX (Brynbach Tower).

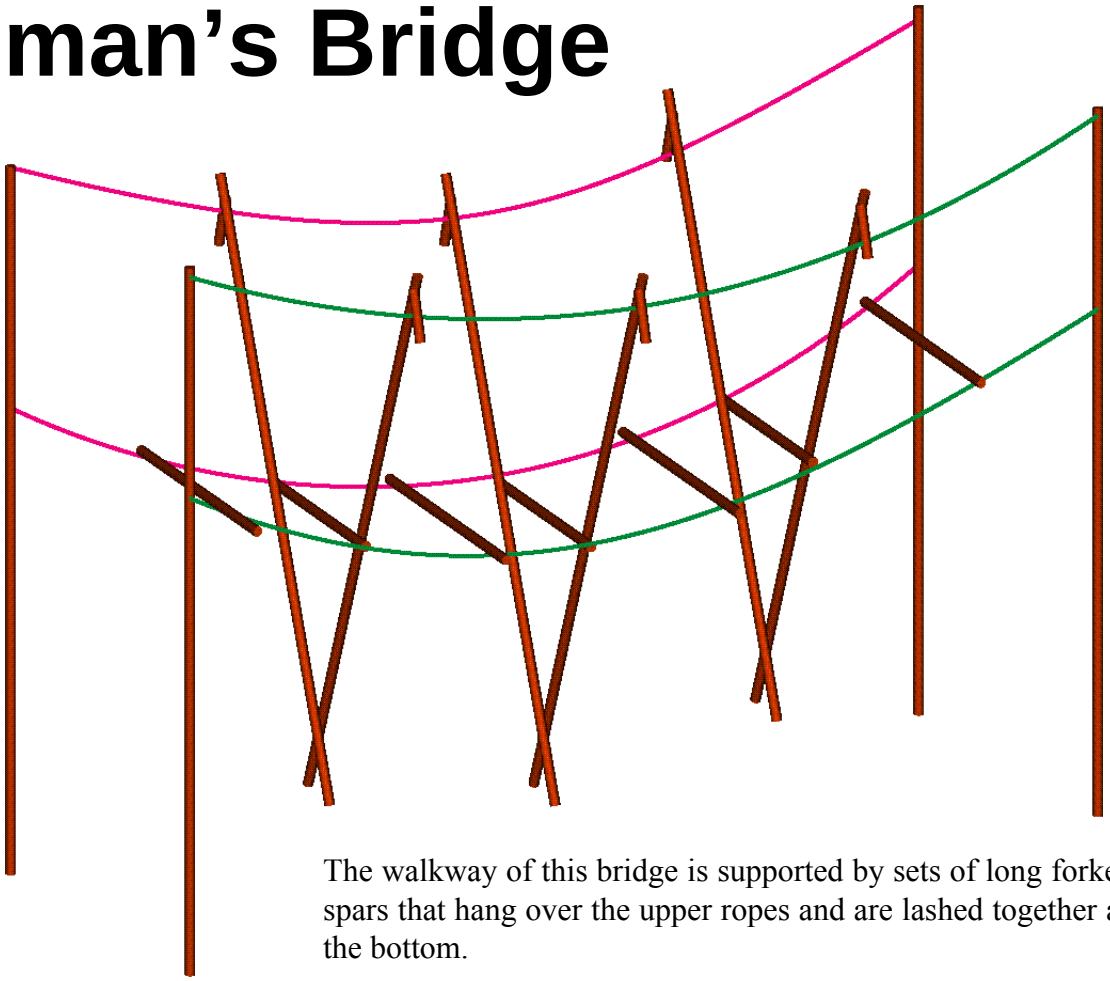
Seine Bridge

Here's a bridge that looks very good, but you need two spars that are long enough to cross the stream and can be bent at the same time, without breaking.



The tripod support pieces rest in the water and there should be two more of them on the other side of the bridge.

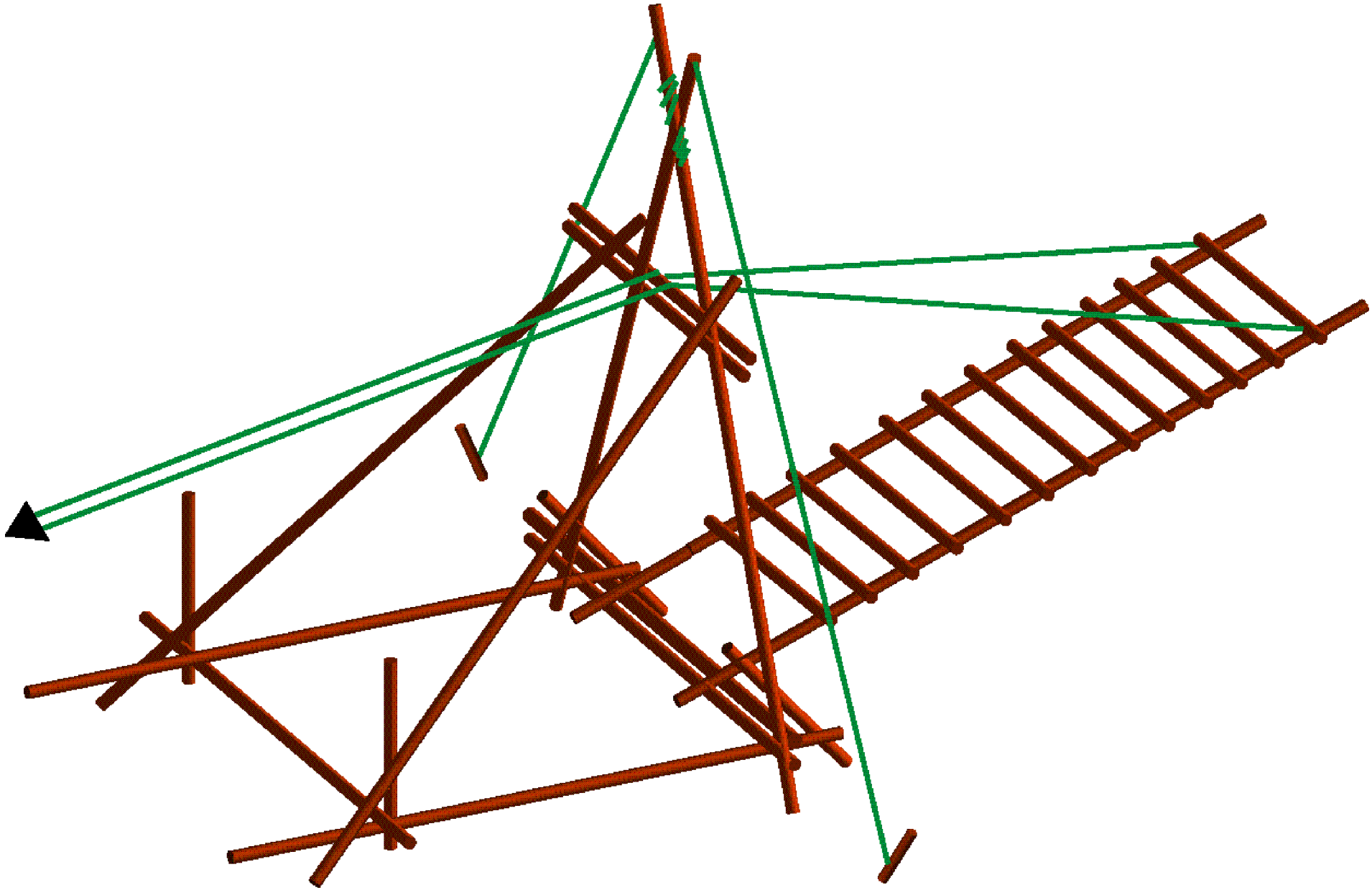
Bushman's Bridge



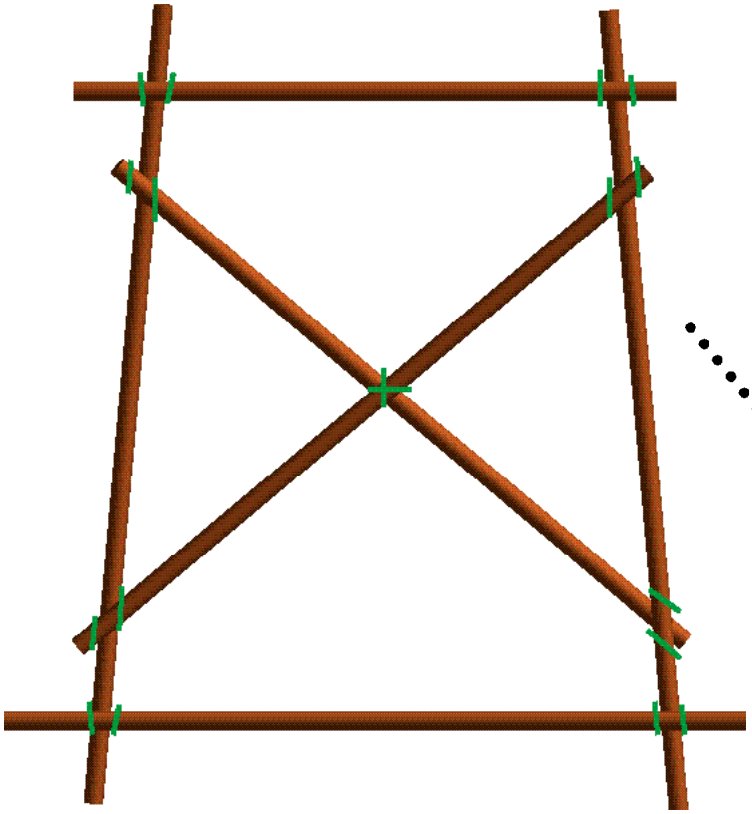
The walkway of this bridge is supported by sets of long forked spars that hang over the upper ropes and are lashed together at the bottom.

In between, the spars of the walkway are lashed across these forked spars.

Draw Bridge

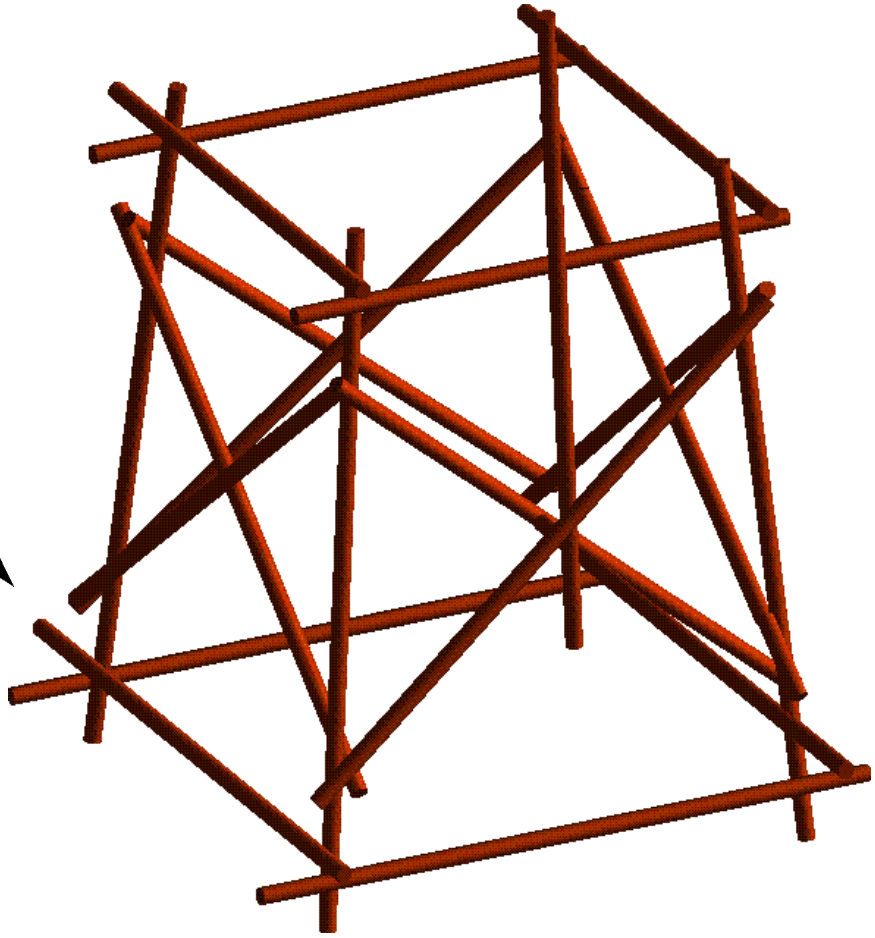


Pylon Bridge

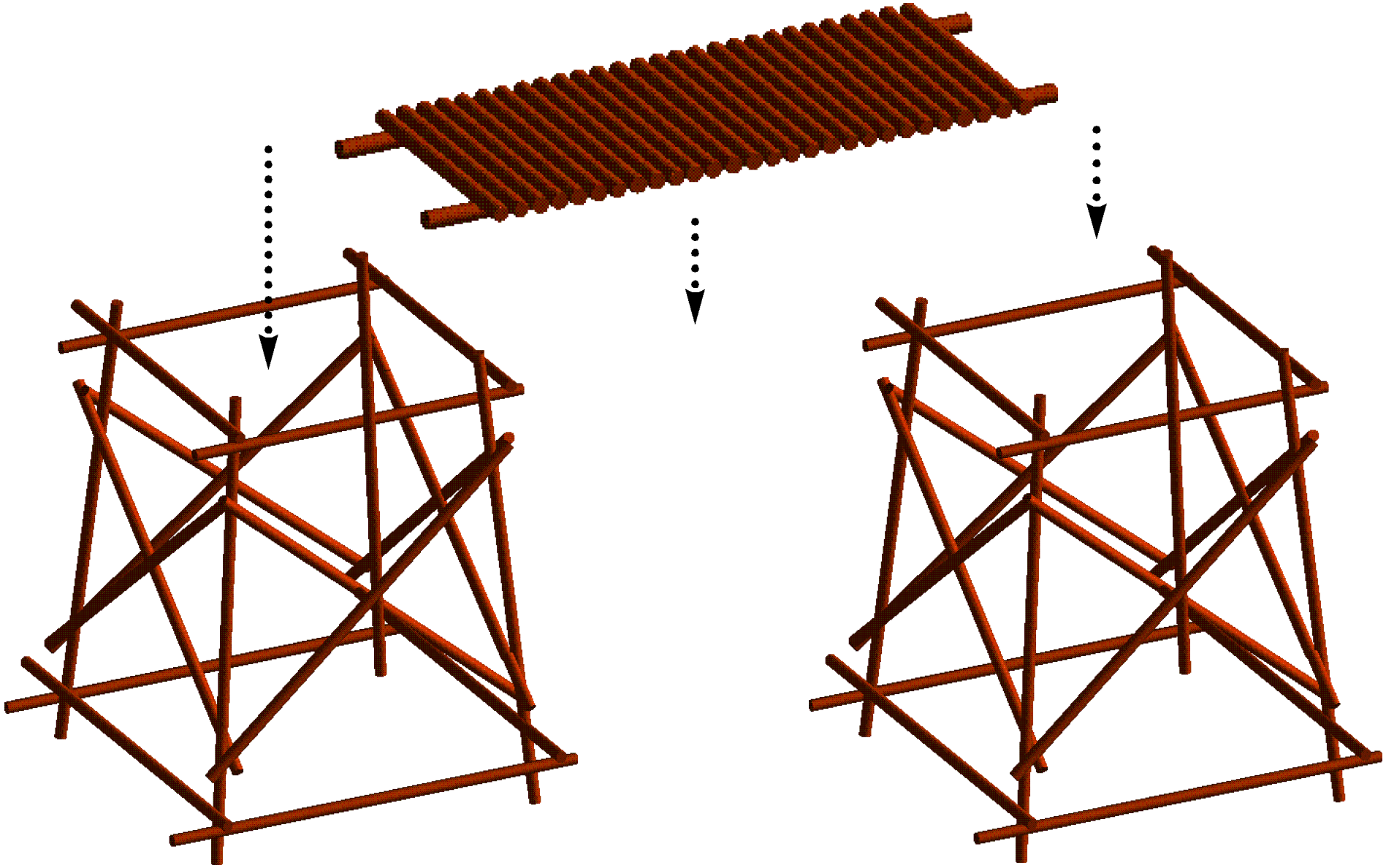


If you need to cross a very wide place, try the Pylon Bridge. Although it seems hard to build, it really is made up of forms you already know -- the trestle and the walkway.

You begin by making a pylon from four trestles placed in a square. These trestles share their sides. Look at the picture of the trestle and then at the picture of the pylon to see how it is put together.

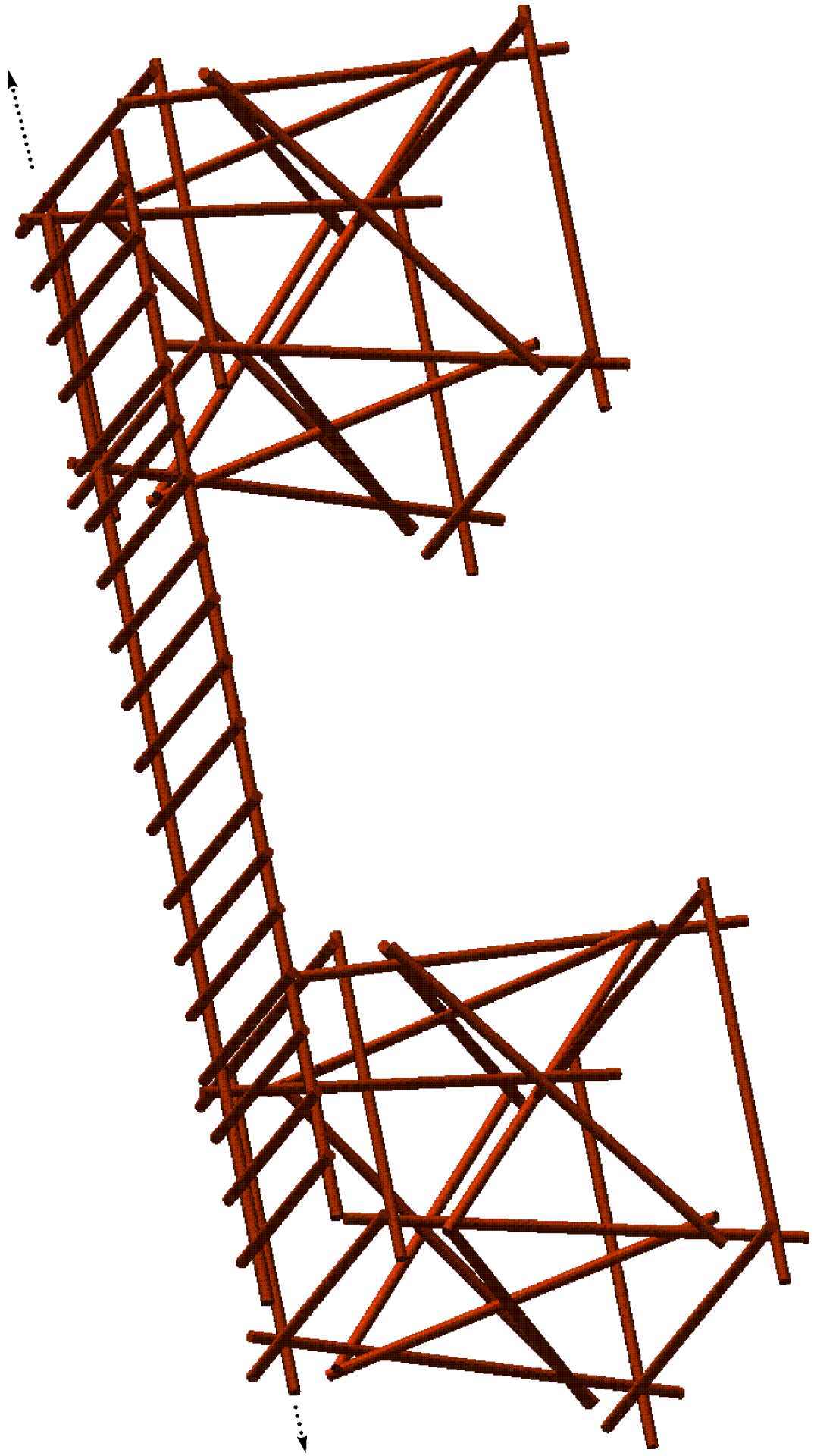


The pylon is very strong and stable. It will be used later to make a tower. But for now it will support the ends of the walkways.



The number of pylons you make depends on how long the bridge needs to be. The walkways should be long enough to reach from the middle of one pylon to the middle of the next one. They should be lashed to the pylons' upper cross-bars using square lashings and to each other where they meet using round lashings. At each end, the walkway needs to go all the way across the pylon. Then ramps can be built from there to the ground.

To finish the bridge, you can add handrails. It takes a lot of work to make the pylon bridge, but it is not difficult. Remember that it is based on two simple parts: walkways and trestles. A picture of the completed bridge is on the next page.

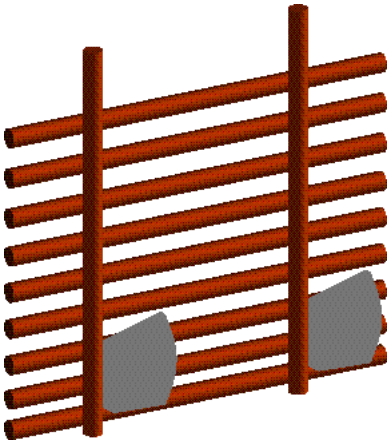


You might ask, “Where do I put the pylons?” They go in the gully or stream. If they are in a dry gully, there is no problem building and placing them. You can put them together in the gully. But what about crossing a river or stream?

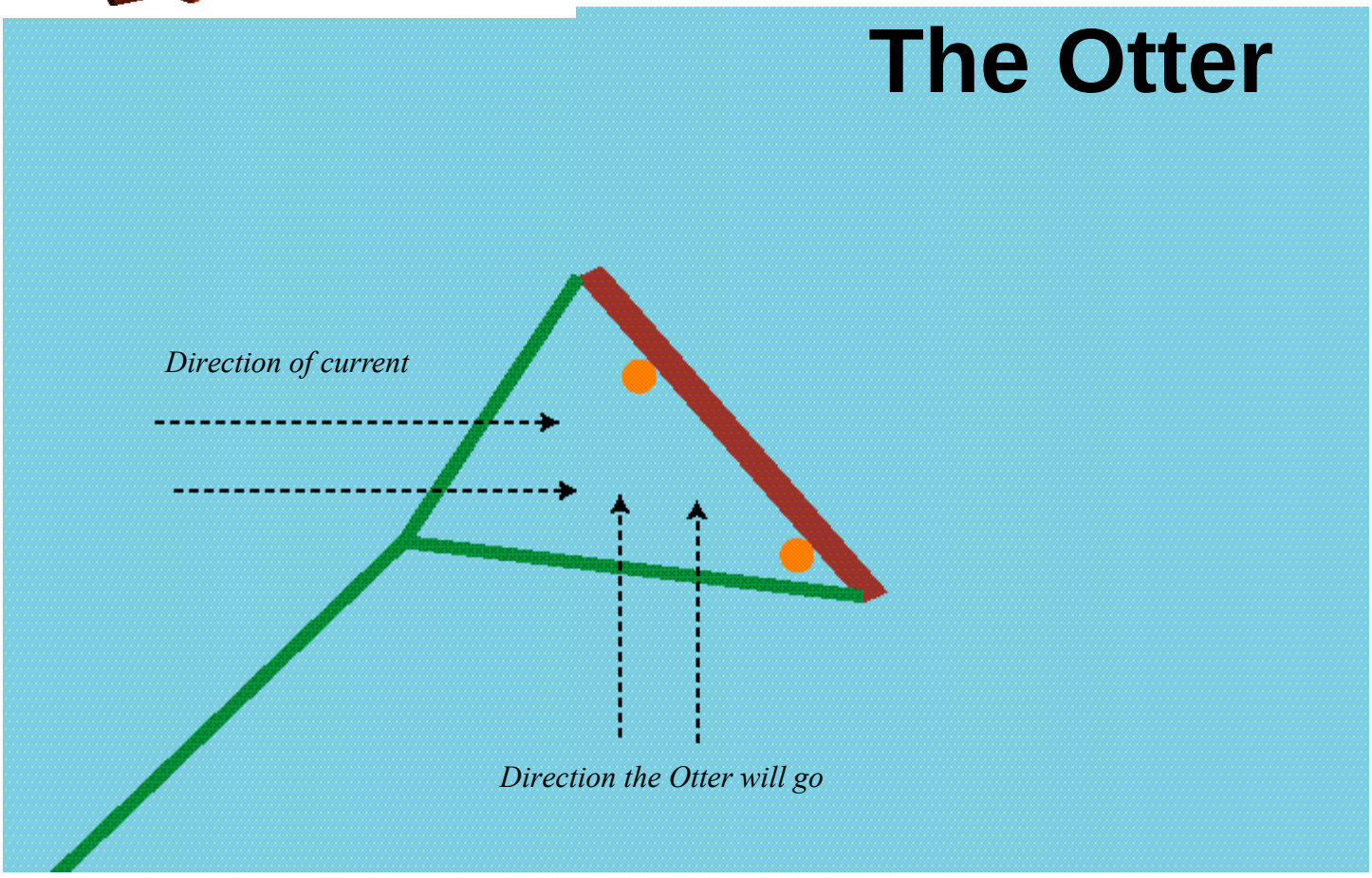
Here’s how to do it.

The first thing you have to do is get across the water without a bridge. If the stream is shallow enough, you can wade out and build your pylons in the water. Wide, deep rivers are no problem, if you have a boat. Have one person stand on the shore and pay out the rope to someone holding the other end in the boat.

If you don’t have a boat but there is already someone on the other side of a fast-moving, deep river, there’s the Otter. Start with several spars lashed to two axes or hammers. Axes are used to keep the Otter from falling on its side and floating away. On the other hand, the wood you use needs to float, or the whole thing will sink to the bottom.

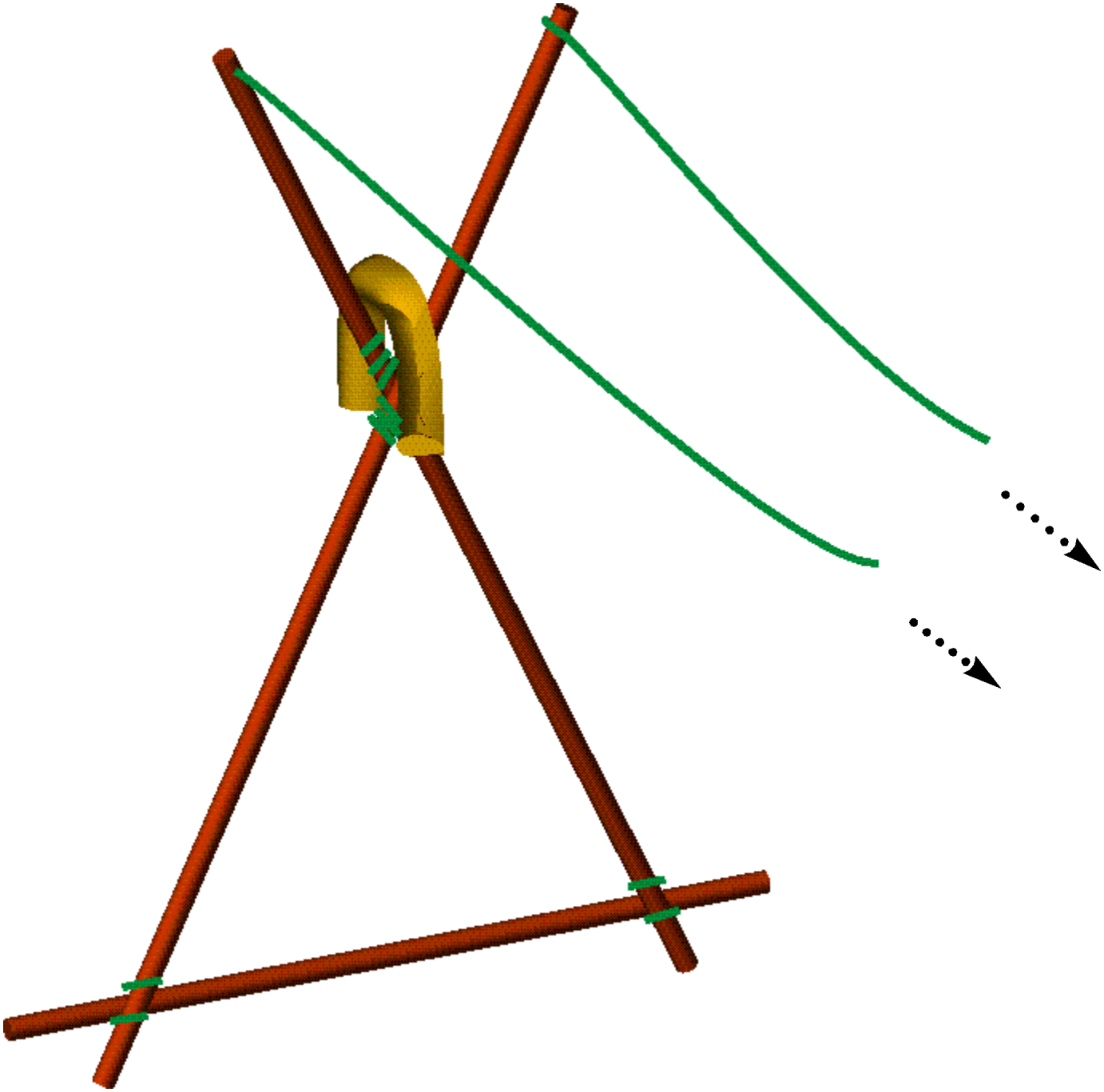


Attach the lines as shown. Notice that one of the pieces of line tied to the Otter is longer than the other. That’s the piece that should be closest to you. The water moves down the river and hits the Otter at an angle. This causes the Otter to be pushed across the river. Make sure you have plenty of line, because the Otter will be far downstream by the time it reaches the other side of the river.

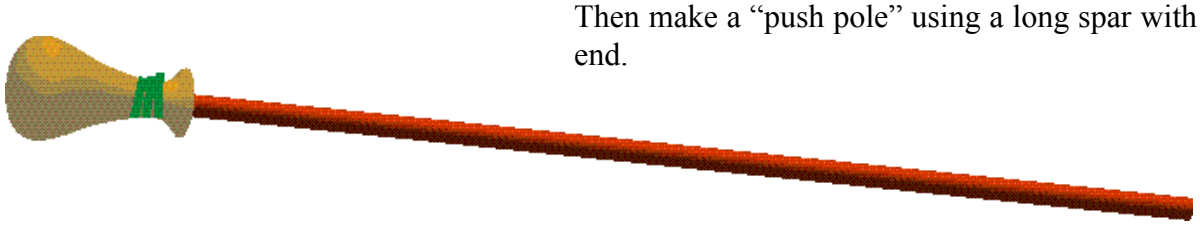


The Transporter

If you need to cross a narrow but deep stream, try the simple Transporter. Begin by making a large triangle with a big "V" at the top. The upper lashing should be a sheer lashing. Put enough padding in the "V" for someone to sit on and attach two long ropes to the top of the legs as shown.

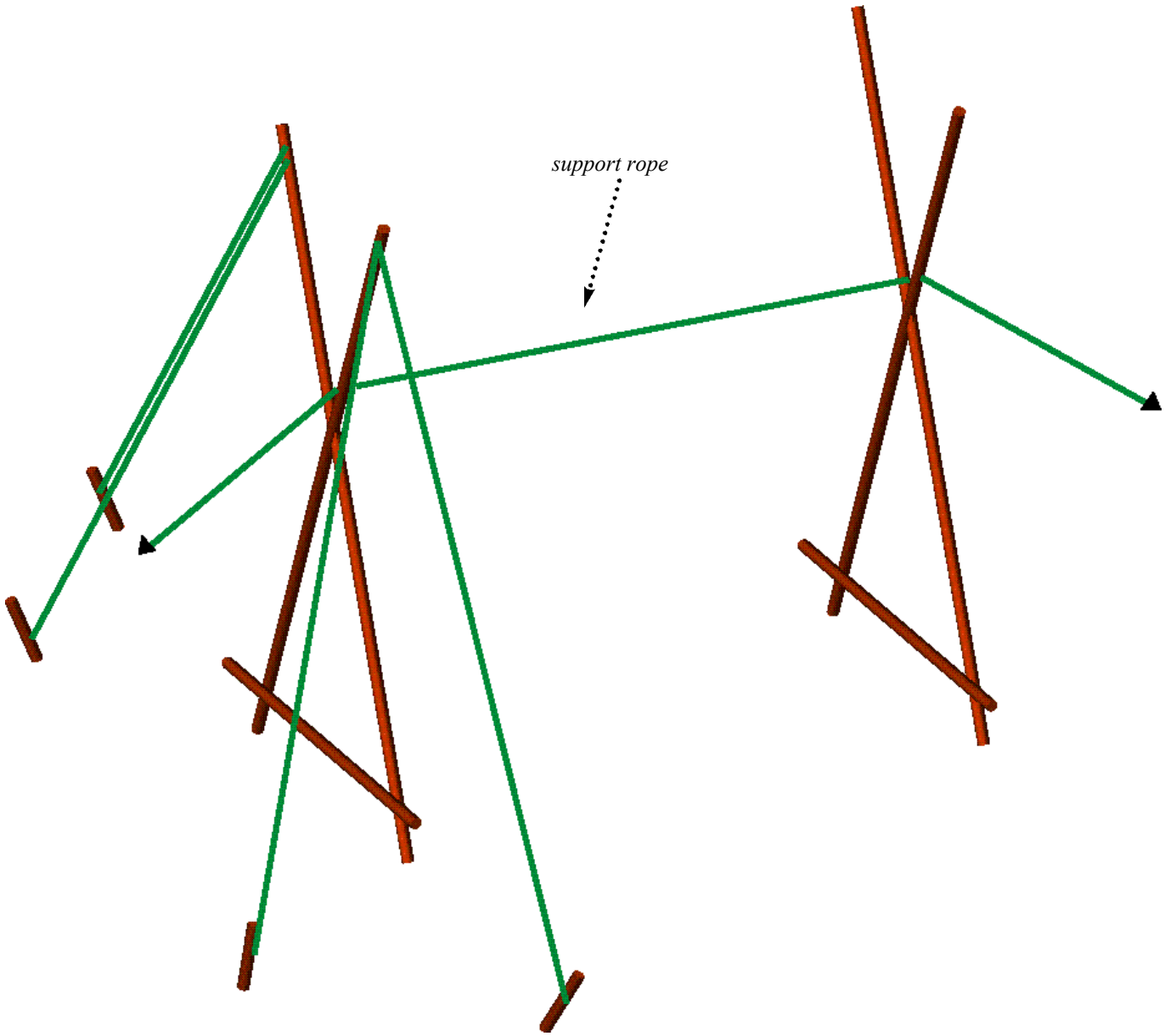


Then make a "push pole" using a long spar with padding on one end.



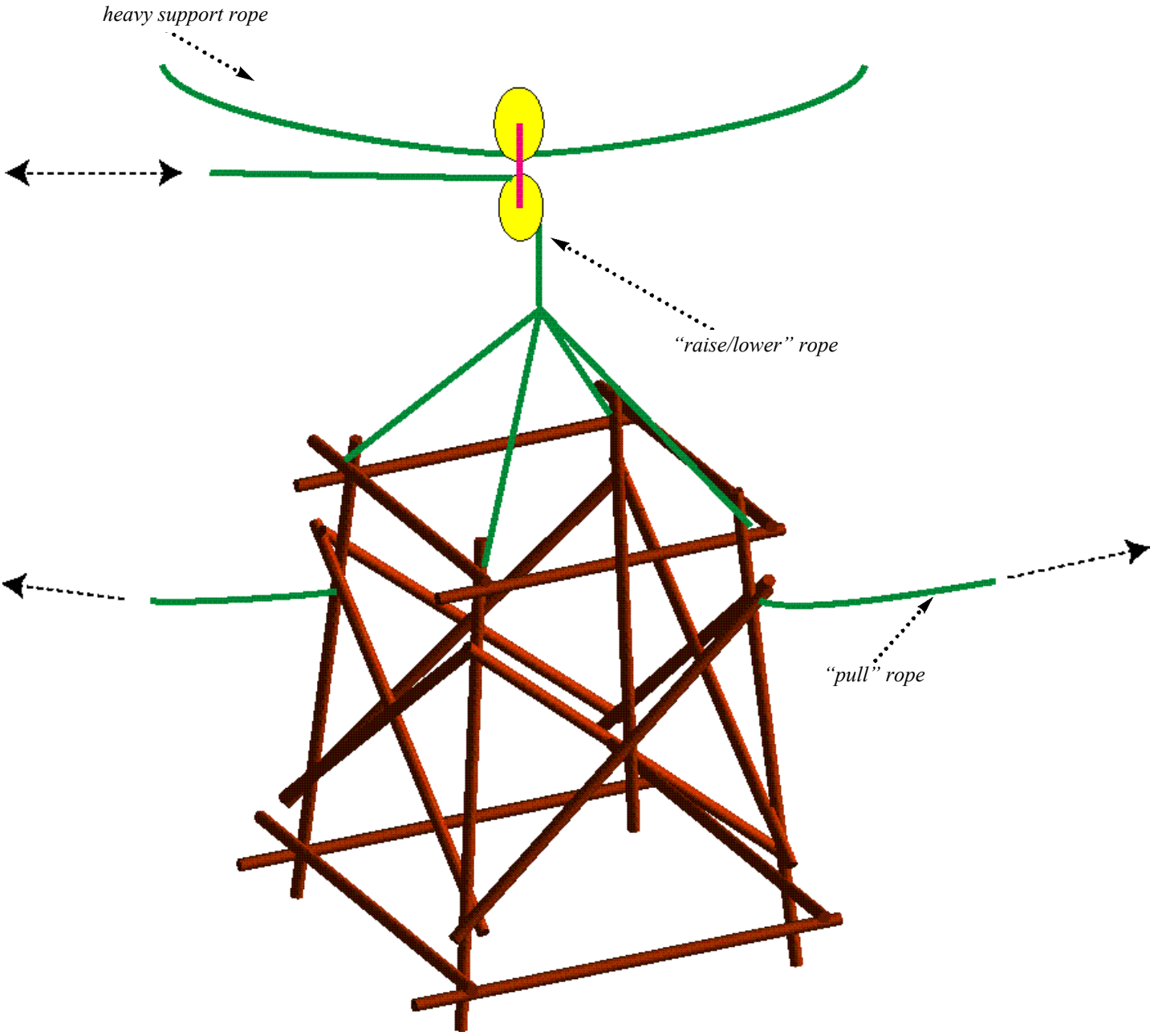
The Transporter needs to be tall enough so that, when your group shoves it out into the stream, the base is halfway across. With someone sitting in the "V," a person uses the padded pole to push the Transporter up and over the stream. Two people hold onto the ropes so that the person does not fall forward too fast. Once two people have crossed the stream this way, they can attach ropes to the top of the Transporter and hold it from the other side. That will give you even more control.

To build a Pylon Bridge over a river that is both deep and wide, you will need a way to get the pylons out into the river. One way was shown earlier in this chapter, using each pylon as a platform from which to launch the next pylon. You also can use a transporter system to position the pylons. Begin with the structure shown below. It is made of two well-braced triangles, one on each side of the river. A heavy rope then is passed over the river between them.



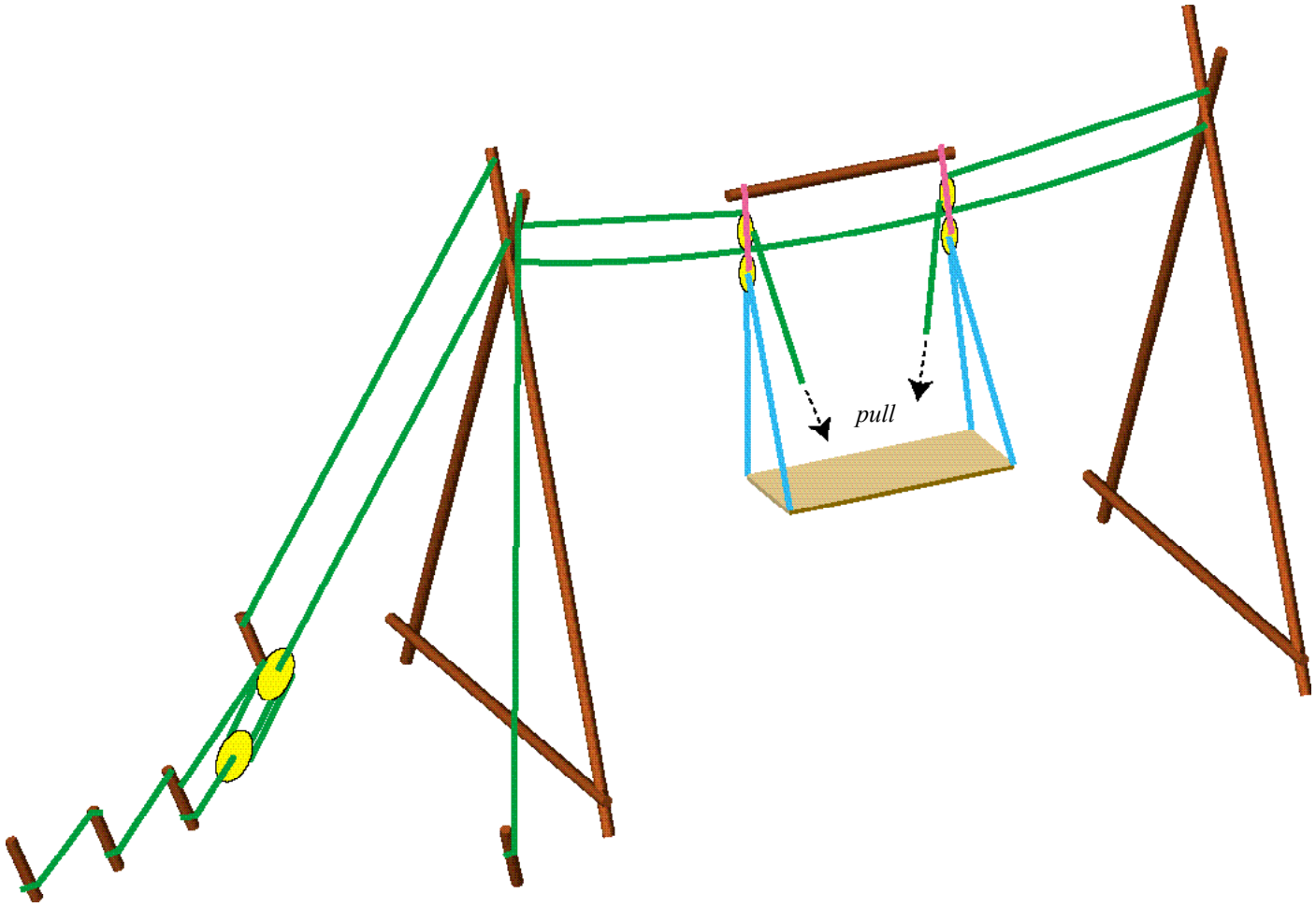
Now you can build each pylon on one bank and, using a simple pulley system, move it across the water and lower it into the river. When the first pylon is set, build a ramp to it. When the second pylon is set, put a walkway between the two pylons, and so on until you reach the other side. As the pylons are moved out over the water, they will twist and sway. Two people standing on the last pylon can use long poles to hold it steady.

Remember that the pylons will be very heavy so the triangles and the support ropes must be strong enough to lift and move them. Also, it takes a lot of people to accomplish the job; you can't do it with just two or three of your friends.



Aerial Runway

Sometimes you will have a river to cross but will not be able to build a bridge. An Aerial Runway might work.

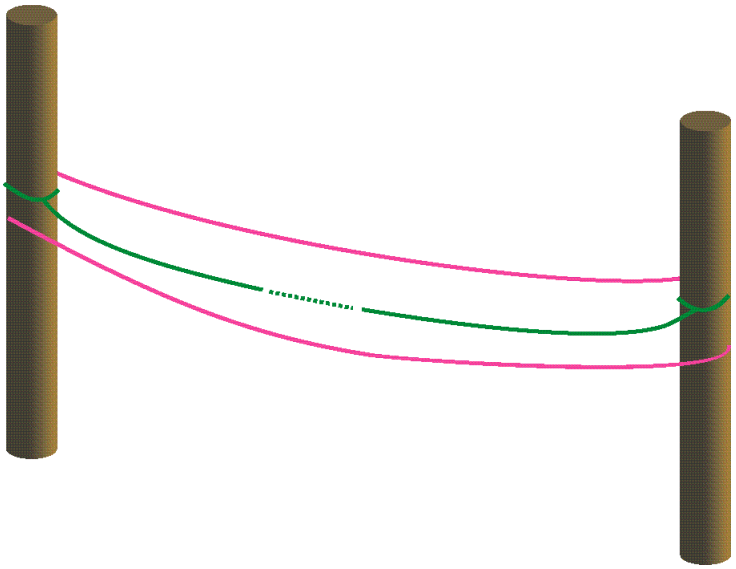


Begin by making a pair of braced triangles, one for each side of the stream. Tie a very strong rope between them as shown. This rope will have to hold a lot of weight, so the triangles need to be well supported. The drawing shows a row of stakes and a block and tackle. (See Chapter XII., Useful Tools, and the X-Bridge for instructions on these and other support methods.)

Make the seat from a board attached to two sets of pulleys, separated by a spar. The bottoms of the upper pulleys rest on the heavy rope. Two more lighter ropes are each tied to the triangles and strung out to and over the pulleys. These are the pull ropes. Be sure that each rope is long enough to reach all the way across the stream. (You also can use a single rope that is tied to each triangle, runs over both pulleys and loops downward between them.)

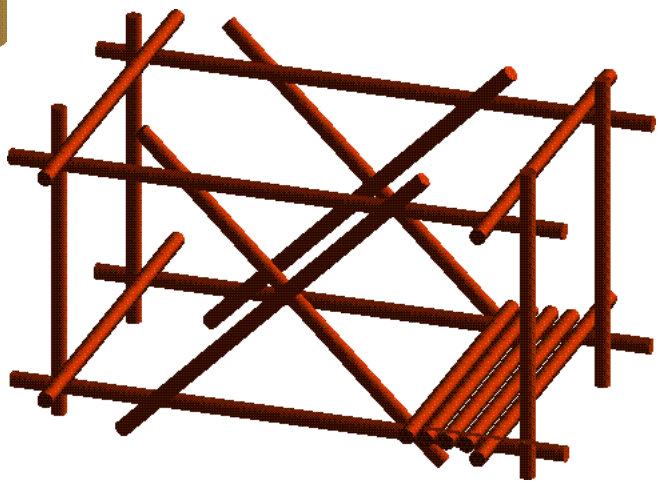
Winched Runway

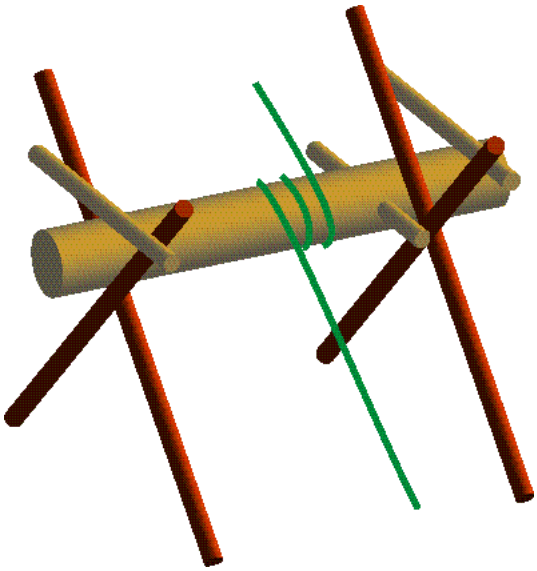
If you have two strong trees on opposite sides of the river and you need something more heavy-duty that will carry a number of people, try the Winched Runway.



First, string three lines between the trees: two heavy lines on either side of the trees and one light pull line from center to center.

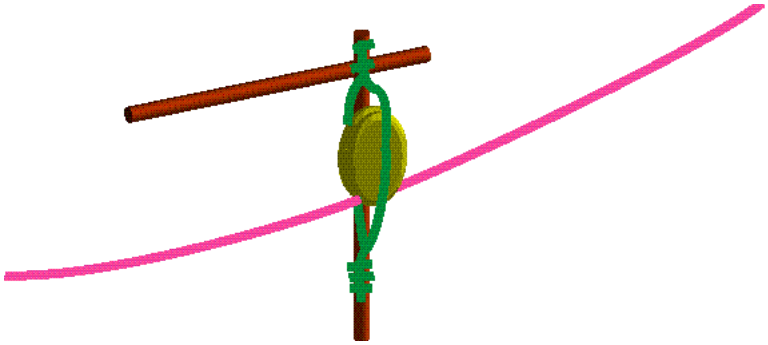
Next, build your cage as shown. Make sure that the side cross-braces are very strong and tightly lashed to the rest of the frame.



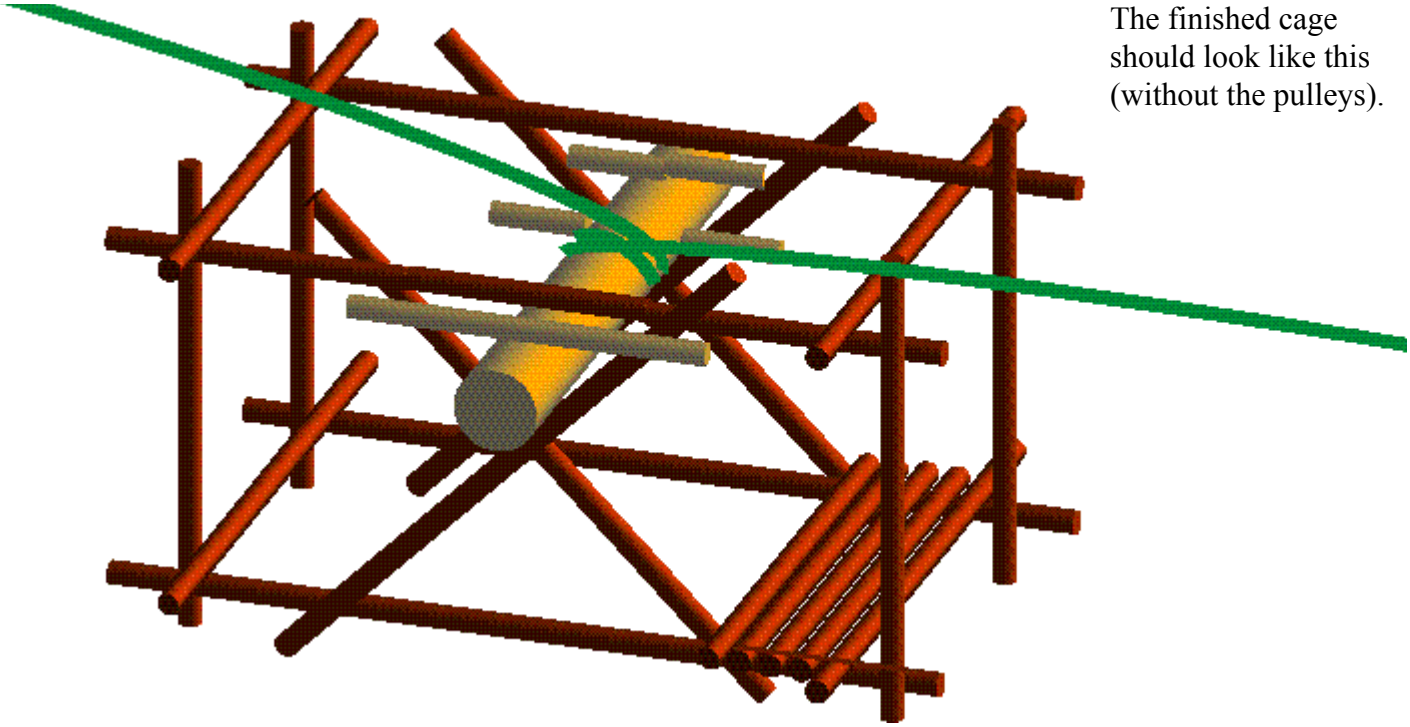


The winch is made using the cross-braces for support. Put a log with some sort of a handle lashed to it between the braces and lash short spars over the ends to hold it in place. The center pull rope will be wound several times around the log.

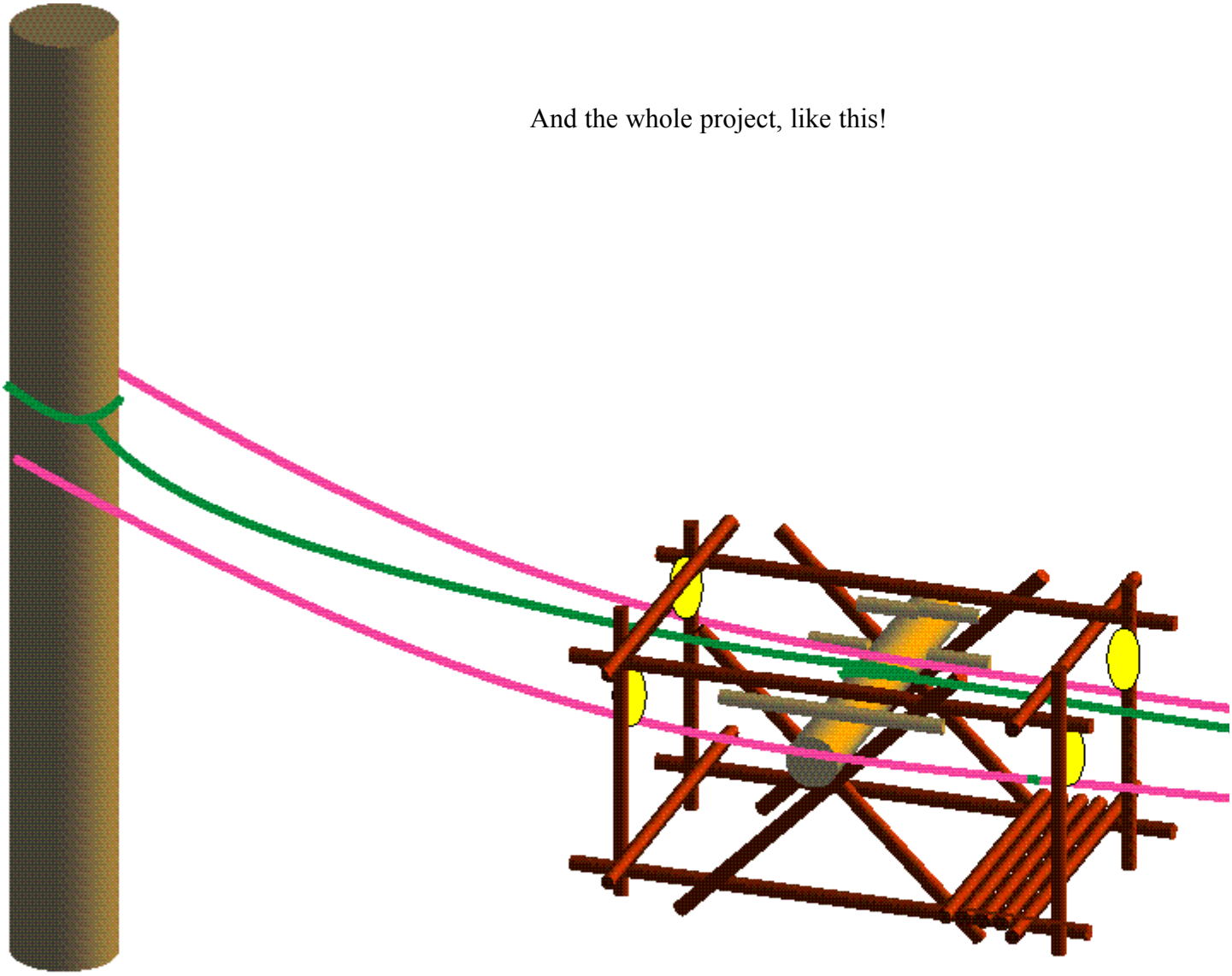
Attach pulleys to the four corners of the cage, making sure they are tied securely at the top and bottom. The heavy side ropes will run under these pulleys.



The finished cage should look like this (without the pulleys).



And the whole project, like this!

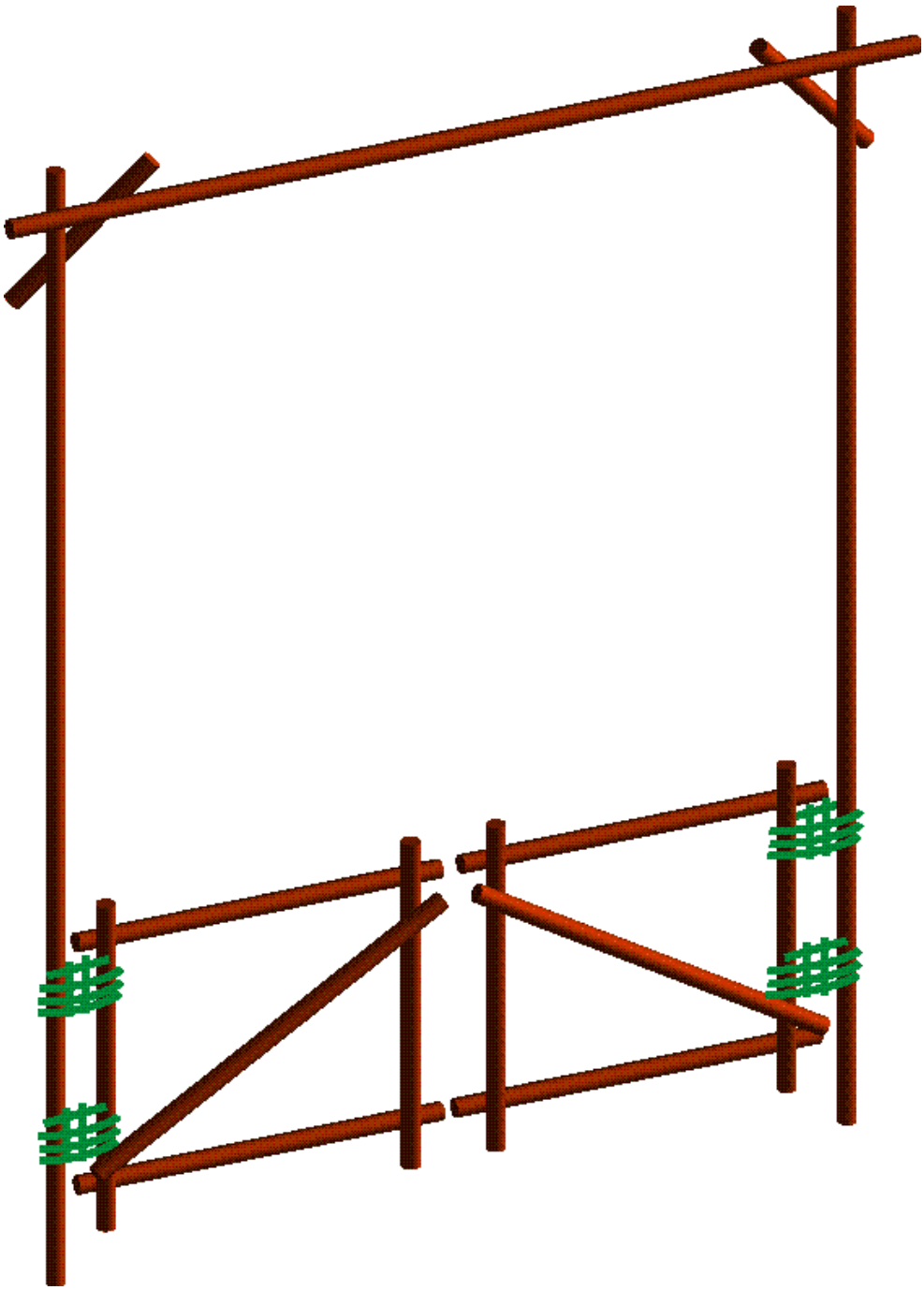


CHAPTER VII
GATES & ARCHES

Swinging Gate With Arch

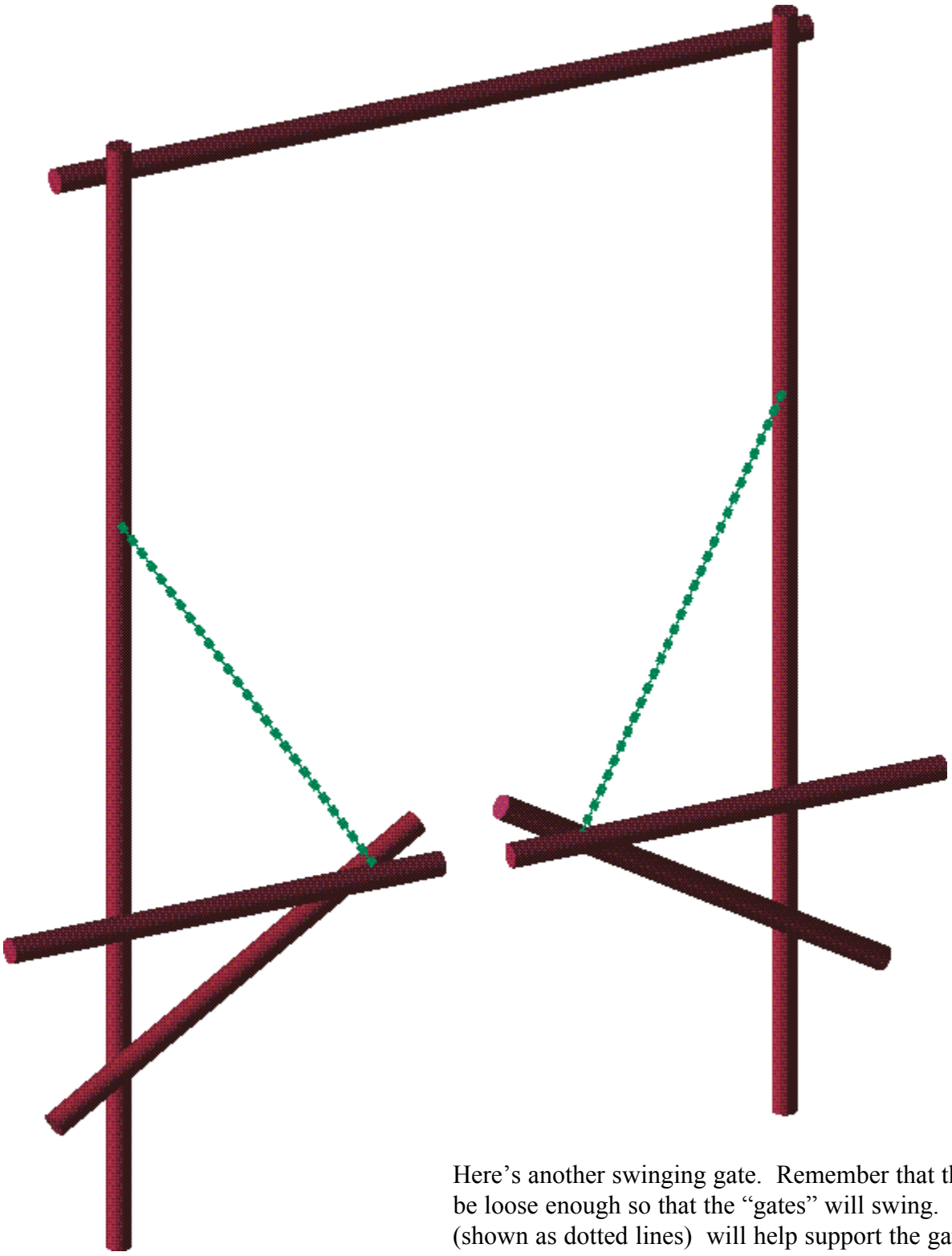
Gates are fun to make because they move. You can build them at home, or when you go camping.

This first gate is a Swinging Gate. It works like a door. The uprights need to be driven well into the ground to provide enough support.



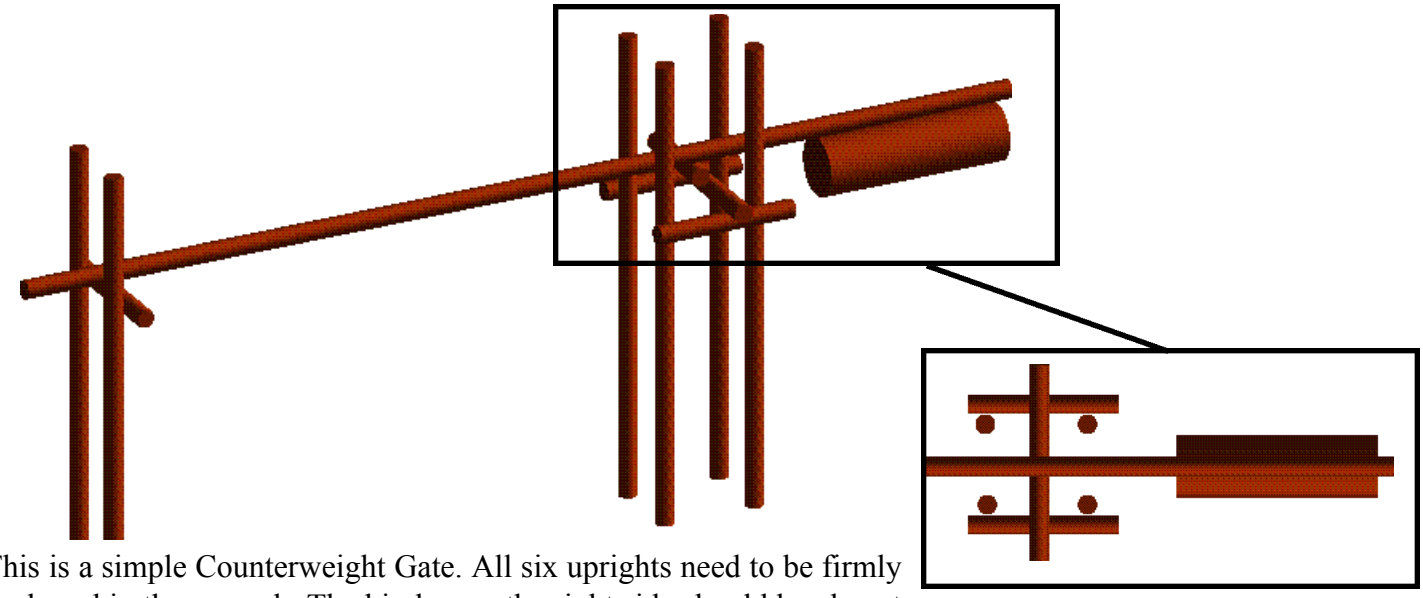
The only hard part is attaching the gates to the uprights. You can use either figure “8” or sheer lashings, but you need to make extra turns and fraps; otherwise, when you try to move the gates they will scrape the ground or bind against the uprights. Do not use rope you will need again, because it will wear as you open and close the gates.

This picture shows the Swinging Gate with tall uprights and a cross-bar at the top. You can make it with short posts or add extra spars to decorate it.



Here's another swinging gate. Remember that the lashings must be loose enough so that the "gates" will swing. The extra ropes (shown as dotted lines) will help support the gates, if they are heavy.

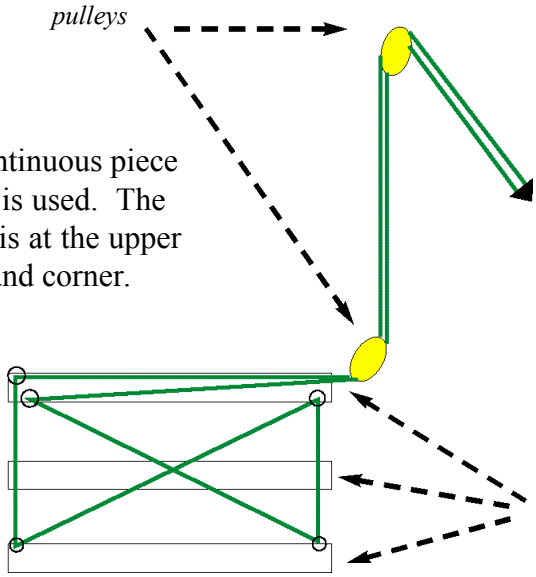
Counterweight



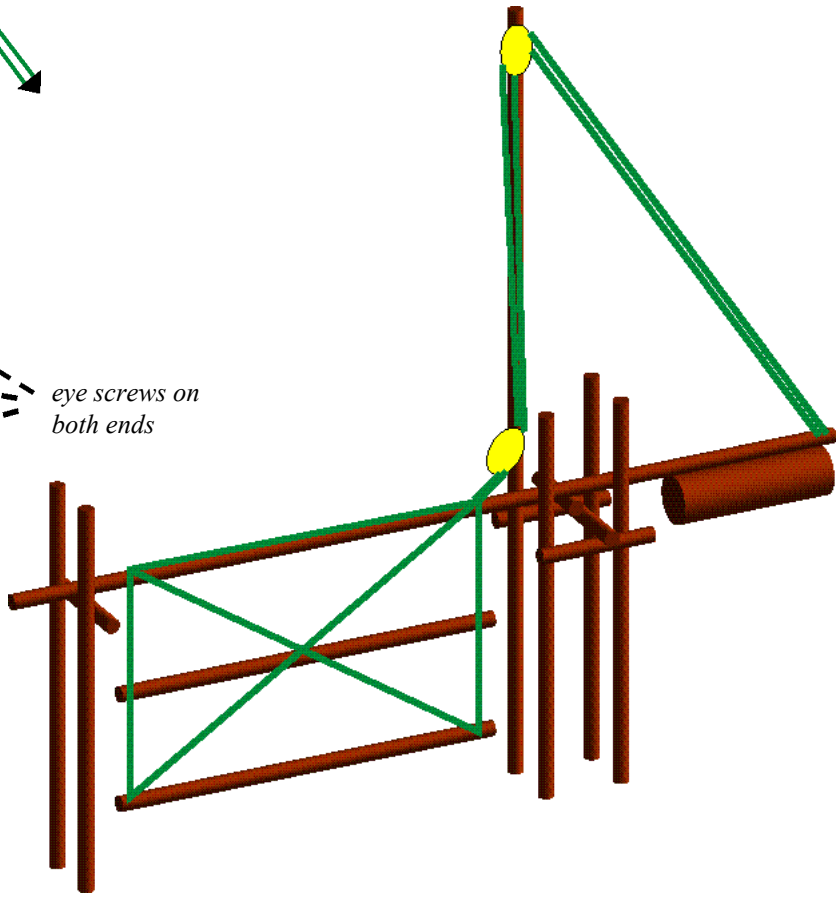
This is a simple Counterweight Gate. All six uprights need to be firmly anchored in the ground. The big log on the right side should be almost heavy enough to make the gate swing up by itself. That way it will be easy for someone to lift the gate, and it will not crash back down.

Top view of "fulcrum."

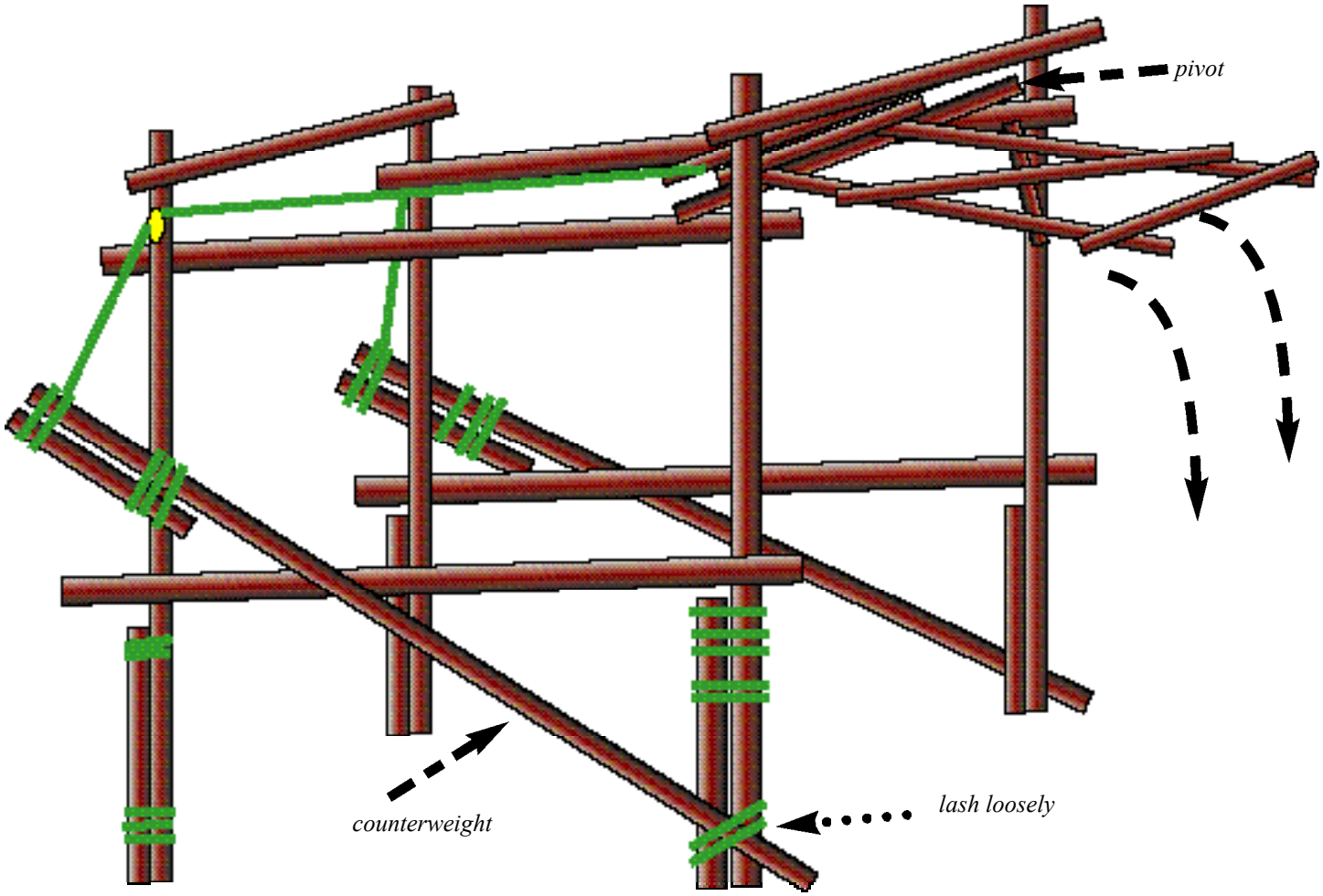
This next version uses a long rope, two pulleys and six eye screws (two on the gate and two each on the "rungs"). When the gate is raised, the rungs will be pulled up just like venetian blinds.



One continuous piece of rope is used. The middle is at the upper right-hand corner.



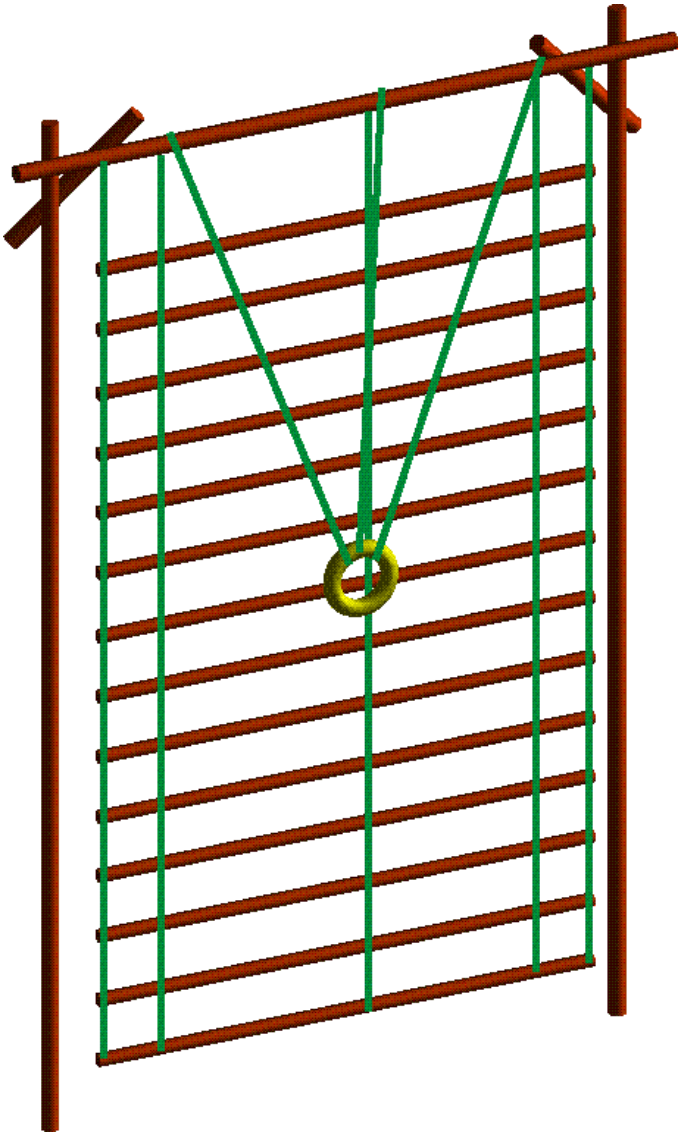
Portcullis

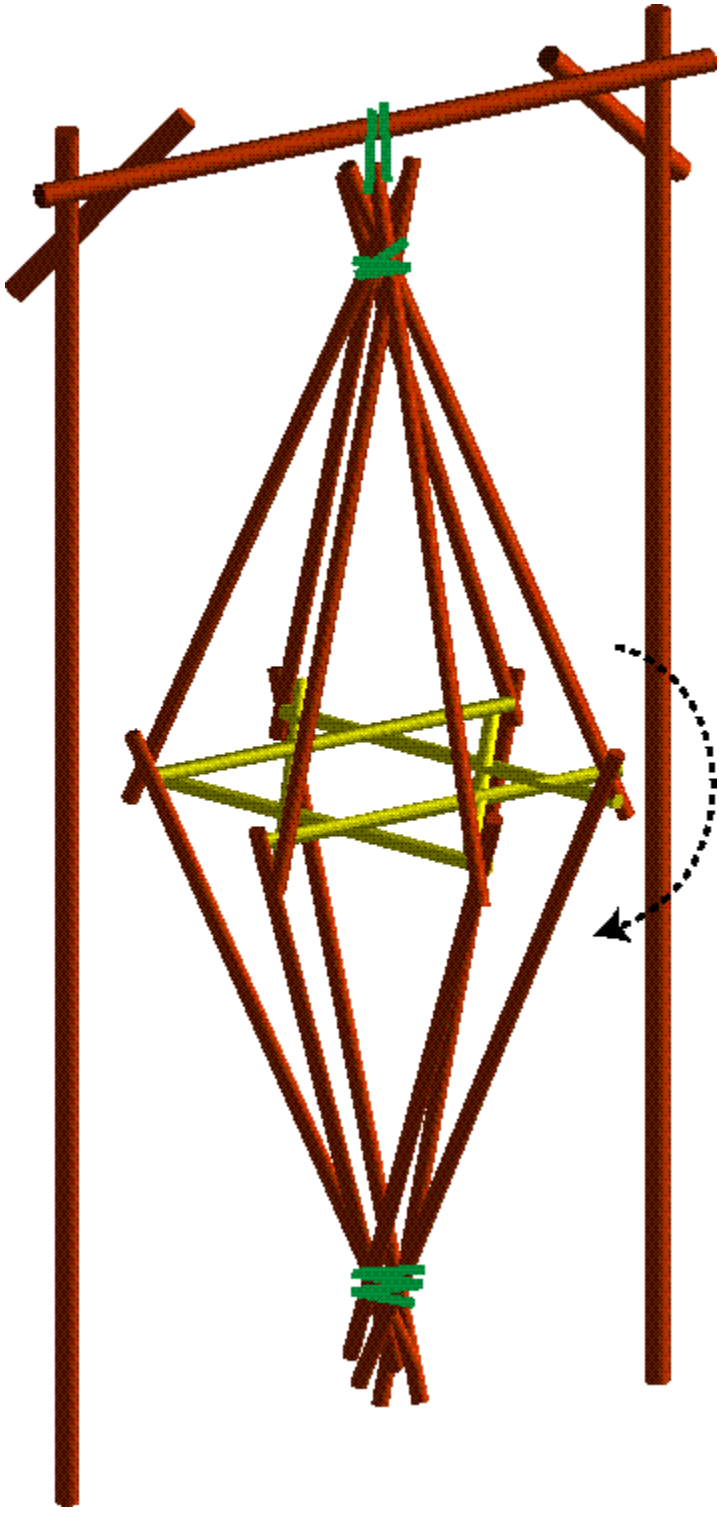


Here's a fancy gate that opens and shuts from the top down. There are two counterweights on each side of the supports. Each is lashed loosely at the front and has a heavy spar at the back to add weight. A line is attached to each that runs through a pulley and is attached to the top of the gate. When the counterweights are pulled down, the gate is pulled up and over a pivot spar at the top. The gate is lowered by raising the back of the counterweights.

Venetian Blind

This gate works just like a venetian blind. Two tall, heavy posts are sunk into the ground and a cross-bar is lashed to the top. Two ropes tied to the cross-bar and to the ends of each spar using clove hitches hold the "slats" in place. The slats should be as light as possible and still be sturdy. There should be three eye screws in the cross-bar, and three in each rung, except for the last, to which three more ropes are tied using clove hitches. Feed the ropes up through the eyes and then down to a pull.

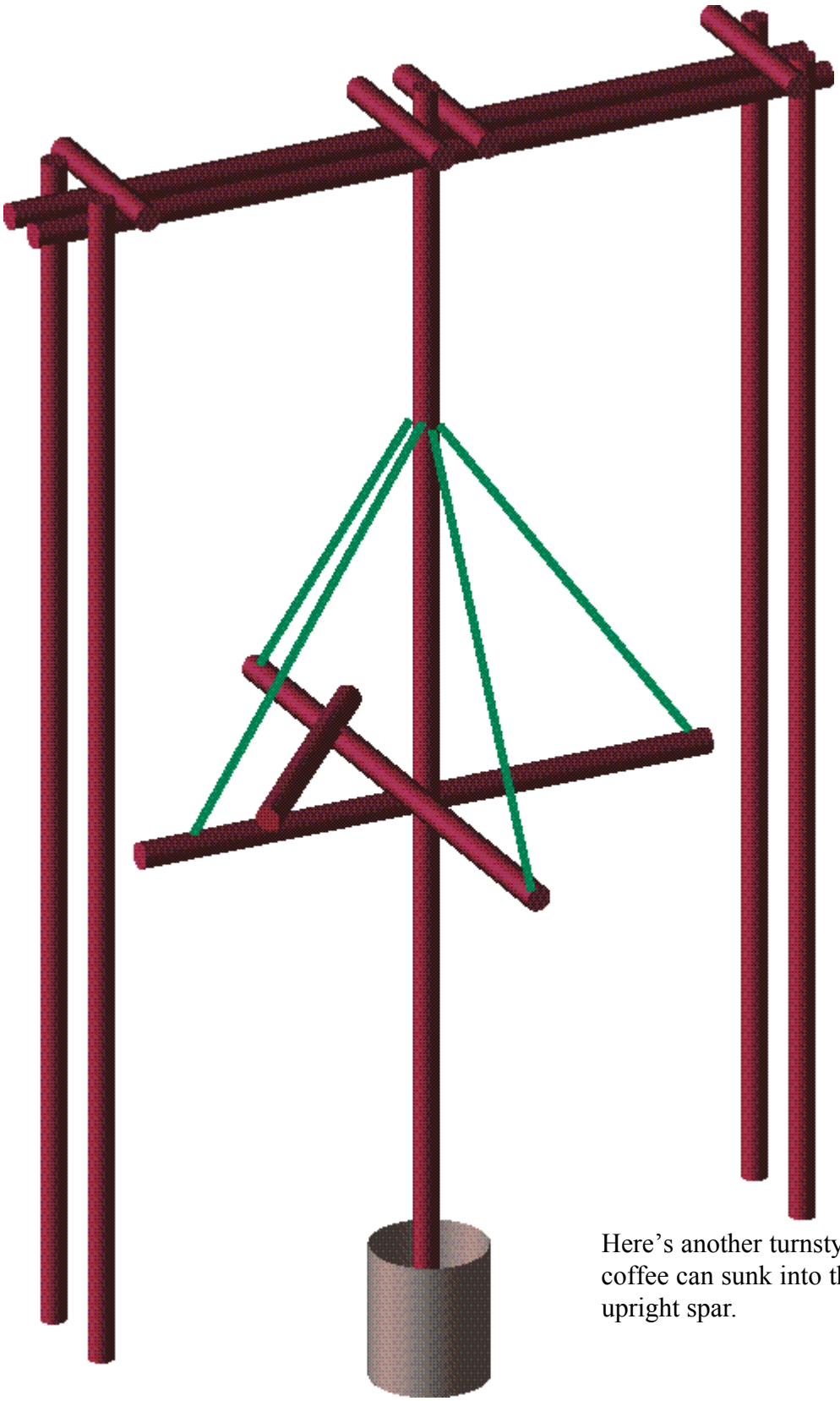




Star of David

This is called the Star of David Gate. The bracing is the same as the Venetian Blind Gate. This gate, however, works like a revolving door. Six spars are suspended from the cross-bar. The six middle braces are shaped like a Star of David, then six bottom spars are added. They are lashed together and may be tied to a stake in the ground, if you want. When you go through the gate, you walk between the points of the star as it turns.

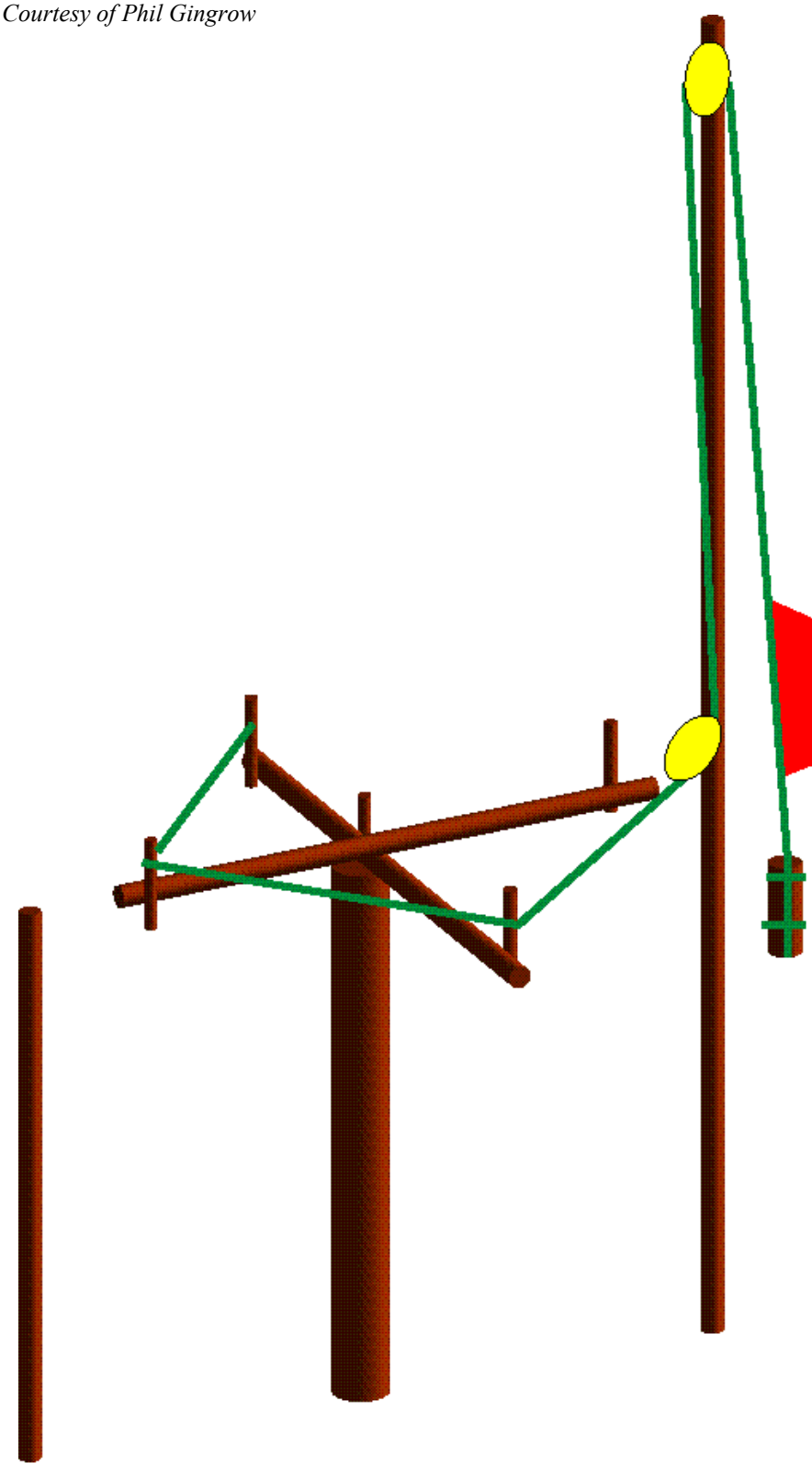
Turnstyle



Here's another turnstyle gate. It uses a #10 metal coffee can sunk into the ground to hold the pivoting upright spar.

Gate and Flag

Courtesy of Phil Gingrow



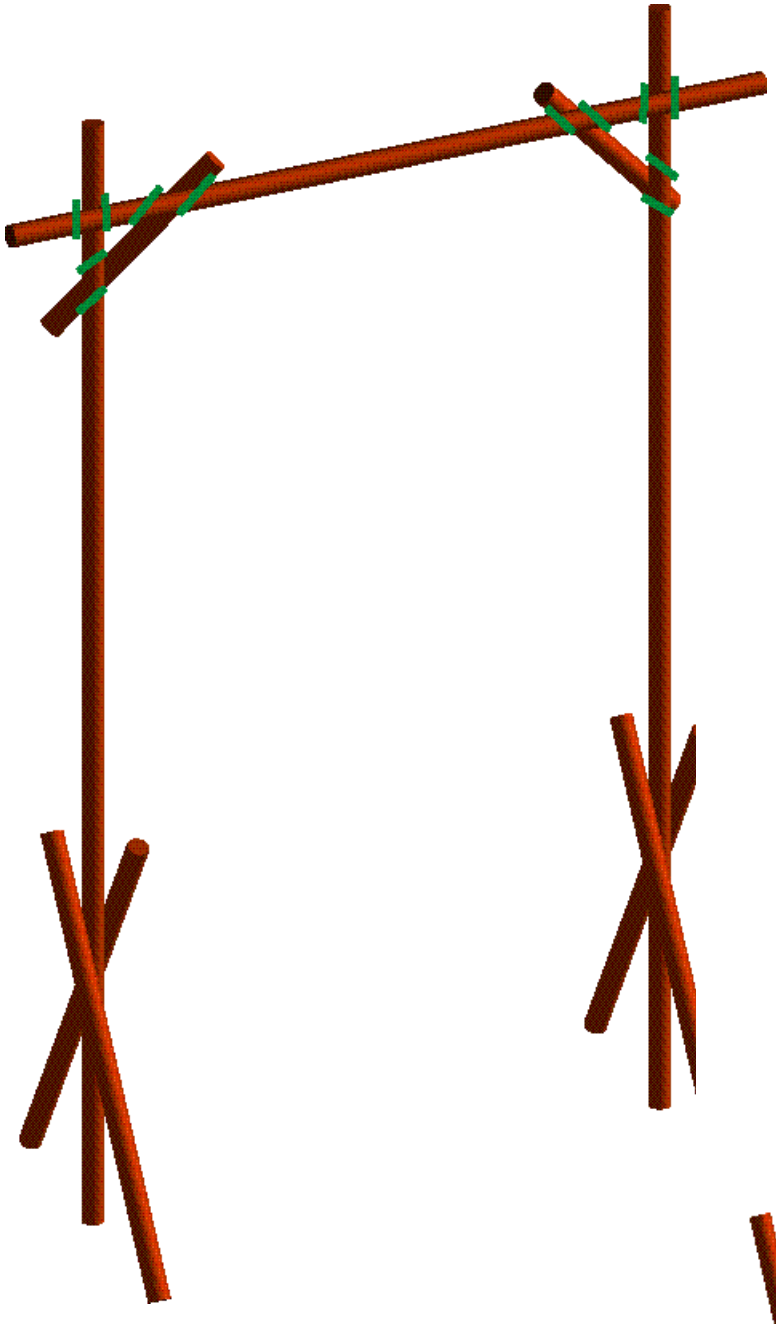
Here's a clever gate and flag combination. The gate itself is like a turnstyle. Drive the center upright spar firmly into the ground. Lash two spars together to form the arms. Drill a hole through the crossed spars and into the post. Use a long wooden peg to hold everything together. Note that the hole needs to be larger than the peg, so the arms will turn, but not so much larger that they wobble.

Then lash four more pegs to the ends of the arms -- or drill holes for them. Next, plant your flagpole and second post on either side of the turnstyle, close to the ends of the arms. Put a pulley at the top of the flagpole and another one lower down, at a height equal to that of the arms. Tie the line to one of the pegs, and loop it around the others, as shown. Pass it through the lower, then upper pulley and down toward the ground. Tie a weight to the line at the end and attach a flag just above it.

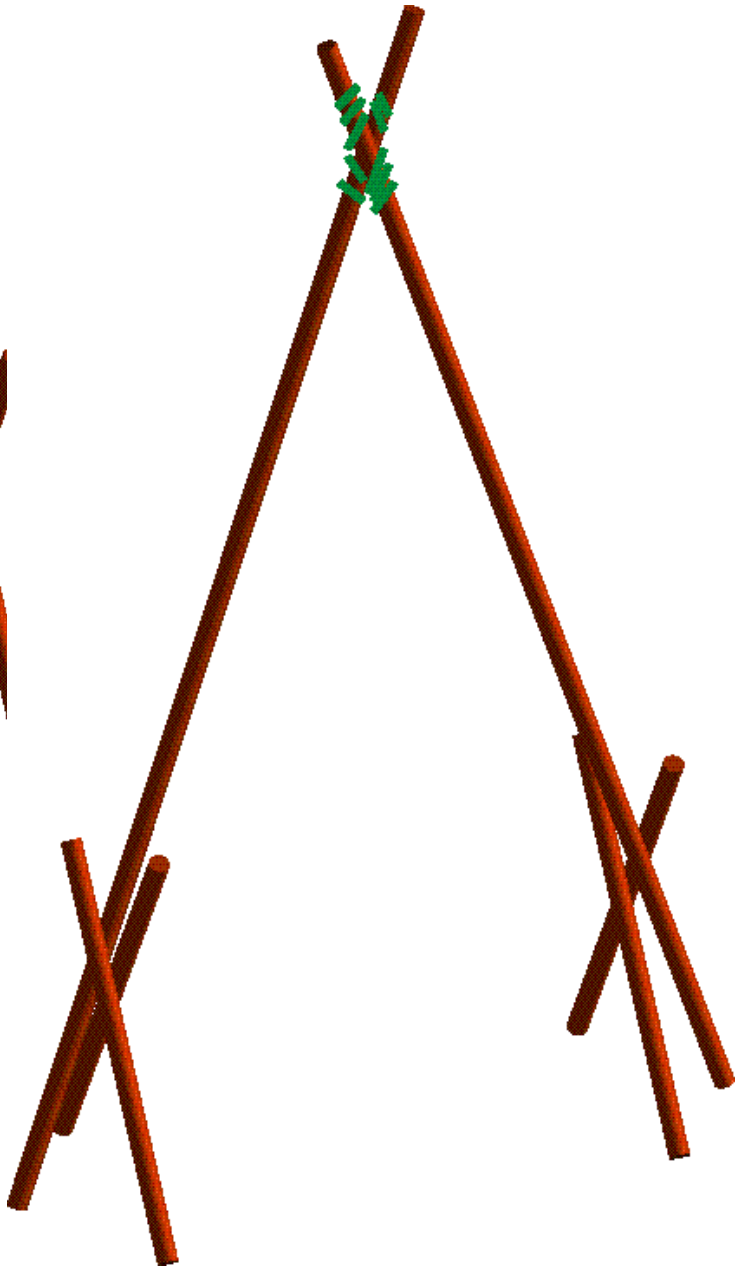
As you enter the gate on the left side, the arms will turn. The line will be pulled around the pegs and the flag will rise. As someone leaves, the reverse will happen, and the flag will lower.

GATEWAYS

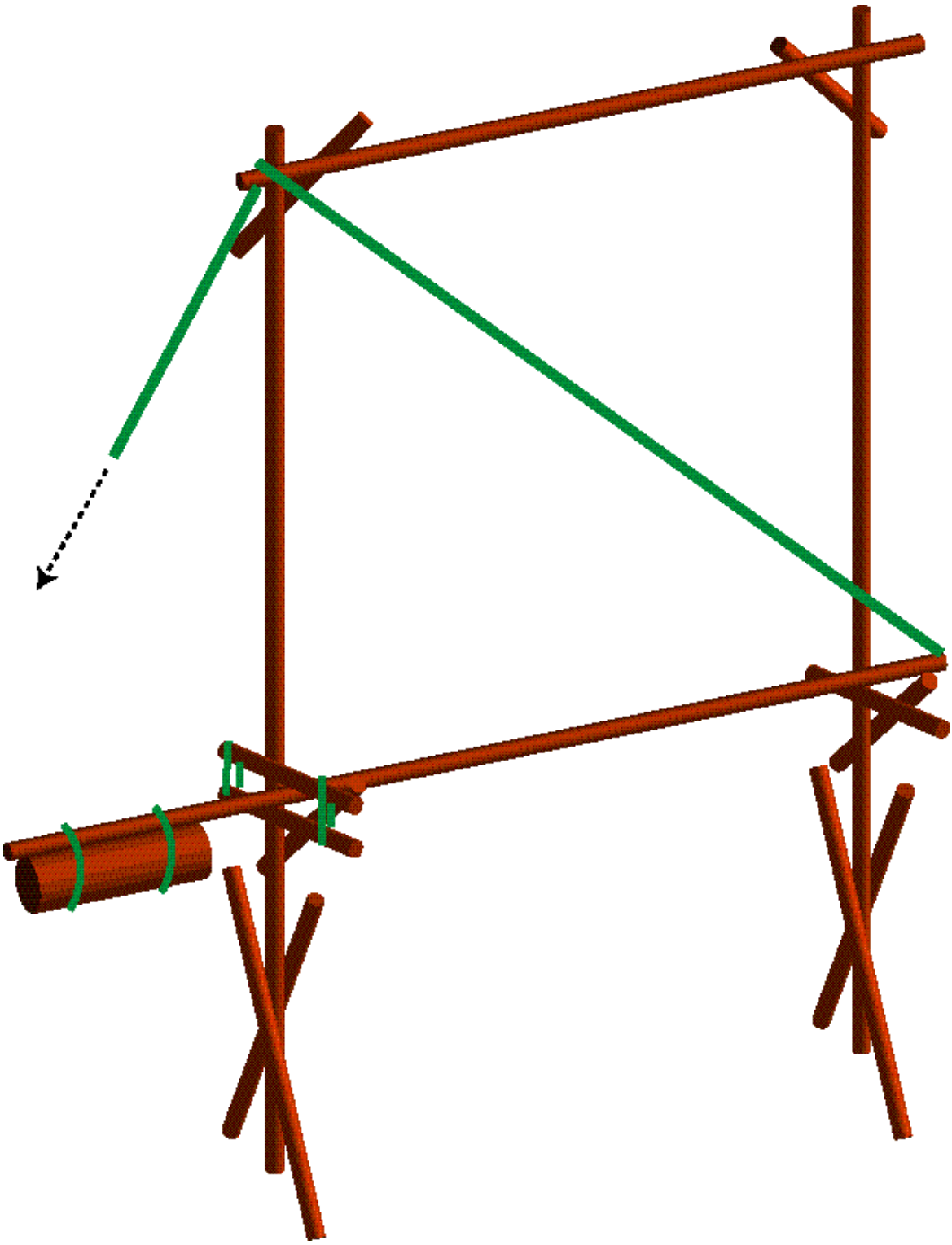
Simple Arches



These are the simplest arches or gateways. The ends of the upright spars should be buried in the ground or braced as shown.



You can decorate them by hanging things from the top.



Here's an arch that has a gate attached. The two short spars on the left upright form the "fulcrum," on which the gate rests. To make the fulcrum strong enough to hold the weight of the gate, two spars are used. Each is lashed to the upright, then they are lashed to each other at both ends. This also keeps the gate from sliding off when it is opened and closed. The gate is raised by means of a rope tied to the end and looped over the top cross-bar. You can tie the other end wherever you want. Notice also that there is a short, heavier log used as a "counterweight" on the end of the gate. This makes it easier to raise the gate and prevents it from crashing down on the cross-bar.

In the next chapter you will find even more arches, made in an unusual way.

Complex Arches and Gateways

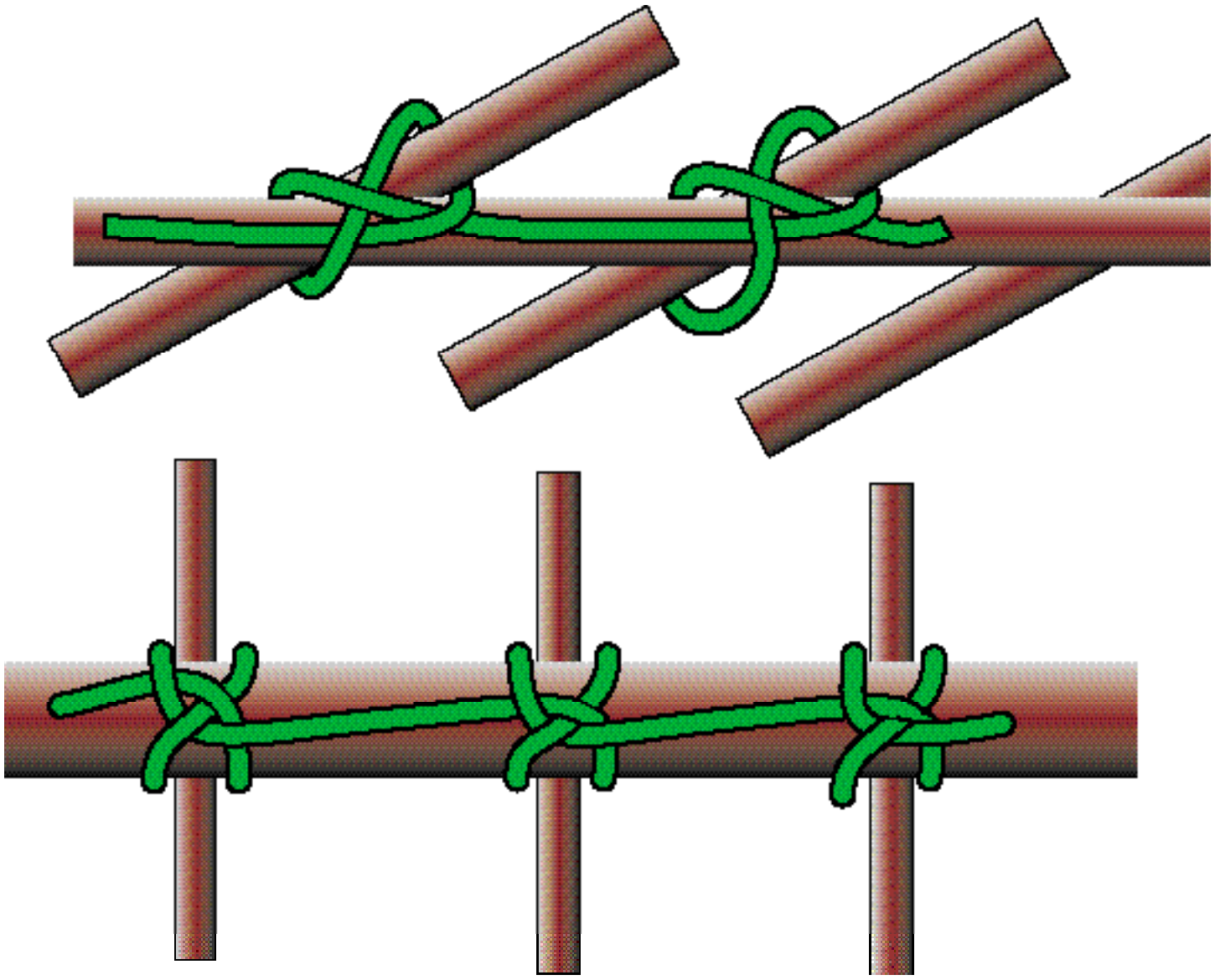
Fancy Gateway

Here's a gateway made with a tower and two tripods. In Chapter IX there are more towers. You could turn many of them into gateways.

Thatched Passageway

An entryway such as this will give you the chance to do some different things. See Chapter VIII for some ideas on how to make your rope sides. You can use a tarp or different kinds of local vegetation to “thatch” the roof. Go to the next page for a new way of putting the roof together. You also could lash this structure on top of a tower. (See Chapter IX.)

African Rafter Lashing



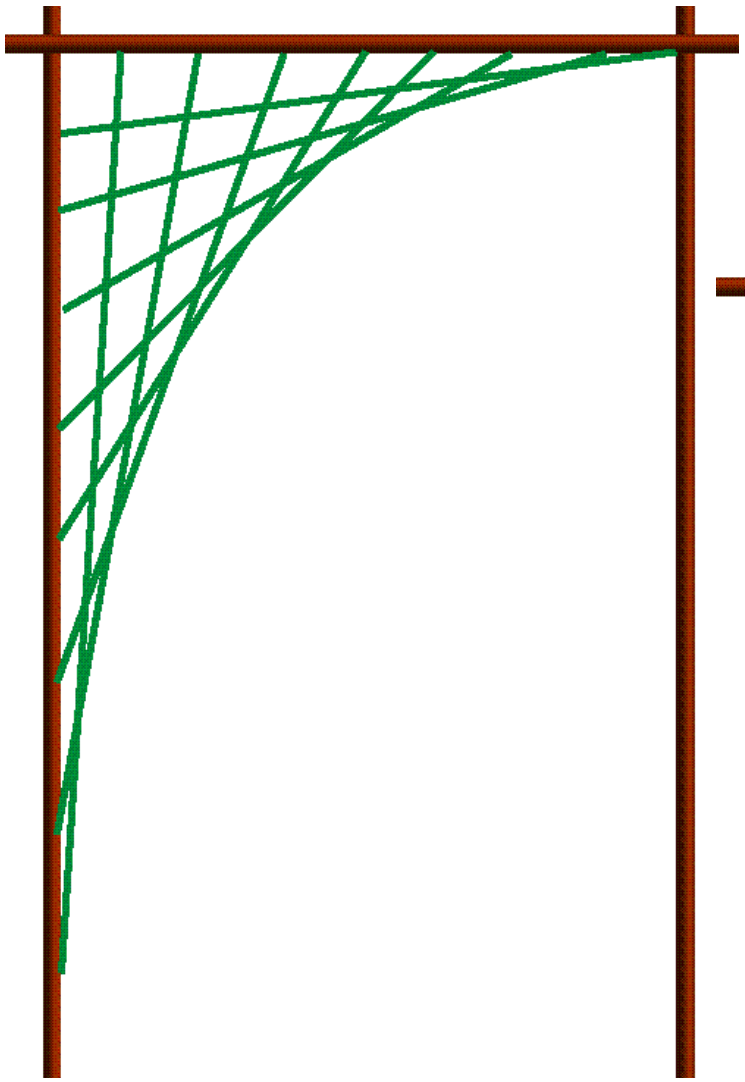
Lash your rafter together using a clove hitch tied around the crossed spars. You will use a little more rope, but you won't have to cut it. Also, it will hold the structure together very well so that the spars will not slip if they get wet or the wind blows against them.

CHAPTER VIII
LINES & CURVES
PH MODELS

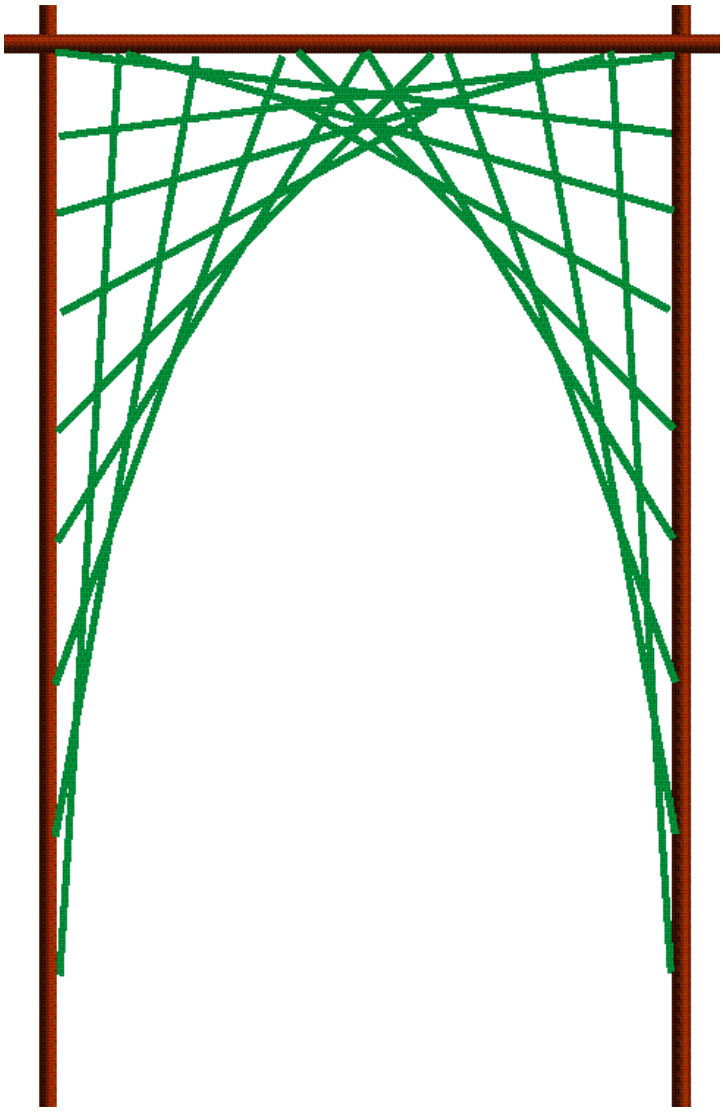
Arches

Up to now, the objects you have made were formed by spars. Rope was used mostly to lash the spars together. These Fancy Gateways use spars as a frame, but their shape also comes from the rope, which is part of the form. Notice how all the ropes are tied from point-to-point, in straight lines, but when the structure is finished, curves appear.

Begin with the basic arch. Mark off a series of points equal distances apart. Then tie a rope from one upright at the ground to the first mark on the cross-bar. Tie the second rope from the next mark up the upright to the next mark on the cross-bar, and so on, until you reach the other side of the cross-bar.



Hint: You will need the same number of marks on the upright as on the cross-bar, so unless the two spars are the same length, the marks on the longer spar (usually the upright) will have to be further apart than those on the cross-bar.

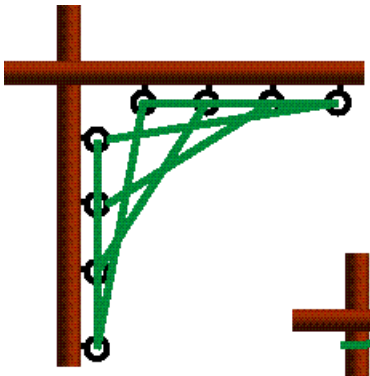


Repeat the process on the other upright until you have a gateway that looks like this one.

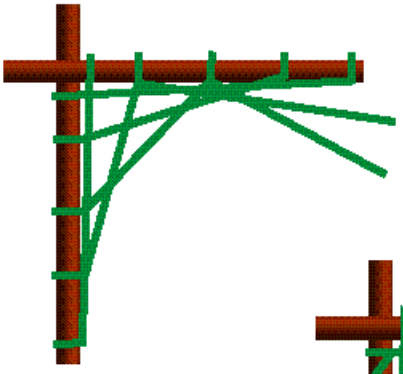
These are known as PH (Paraboloide Hyperbolique) projects.

You do not need to use separate ropes each time you go from upright to cross-bar.

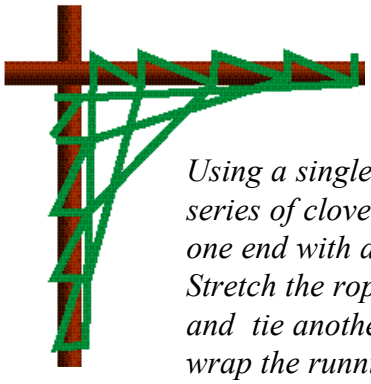
Here are three other ways of tying the rope off so that you can use longer ropes or even a single length.



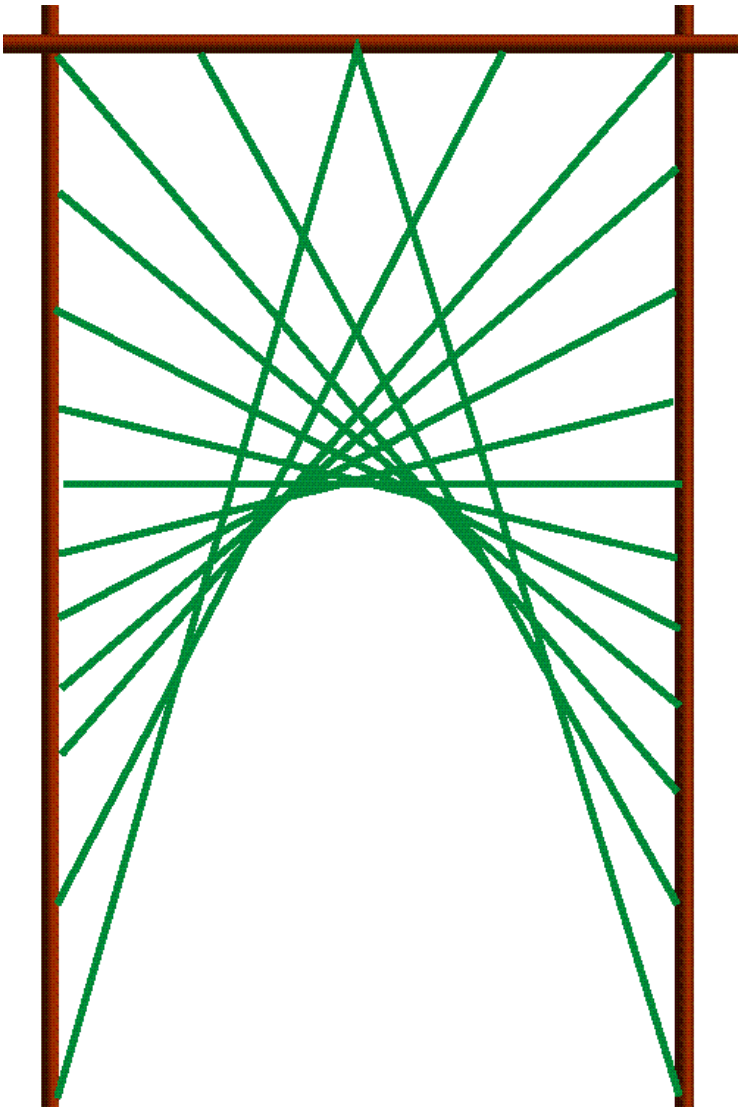
Using a single length of rope and eye screws.



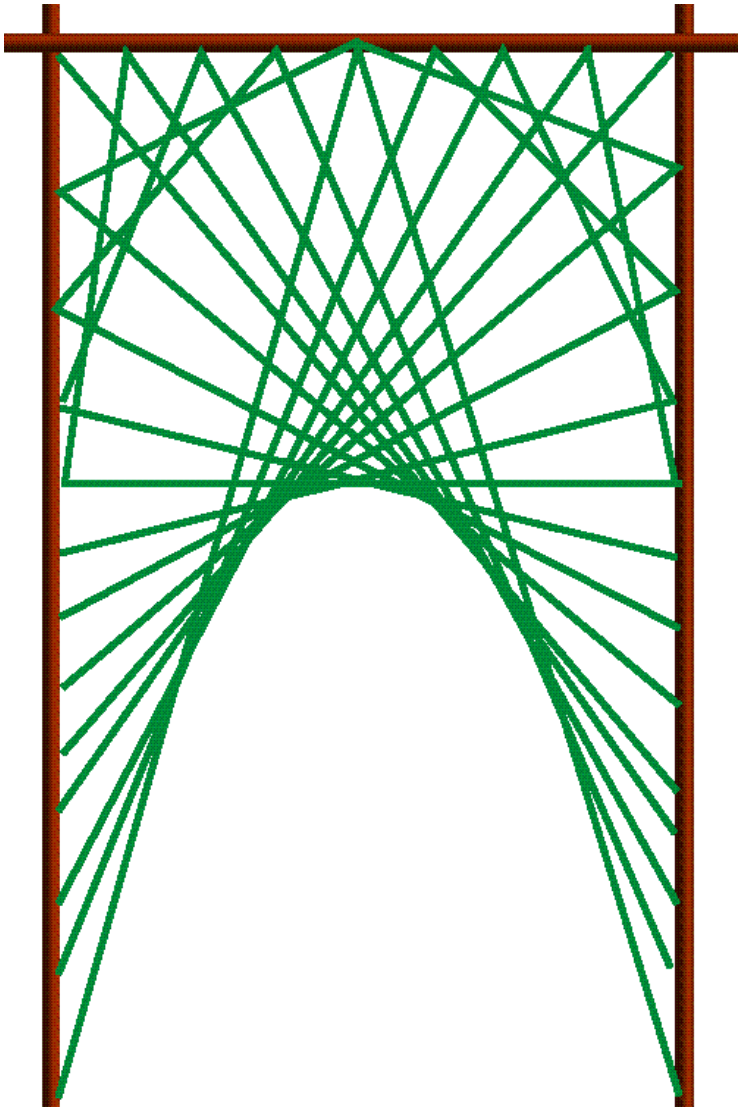
Using one length of rope for each pair of spars by tying a clove hitch around the spar in the middle of the rope



Using a single piece of rope and a series of clove hitches. Begin at one end with a clove hitch. Stretch the rope to the other spar and tie another clove hitch. Then wrap the running end around that spar to the next mark, tie another clove hitch, and string the rope back to the first spar. Keep on until you have reached the other ends of the spars.

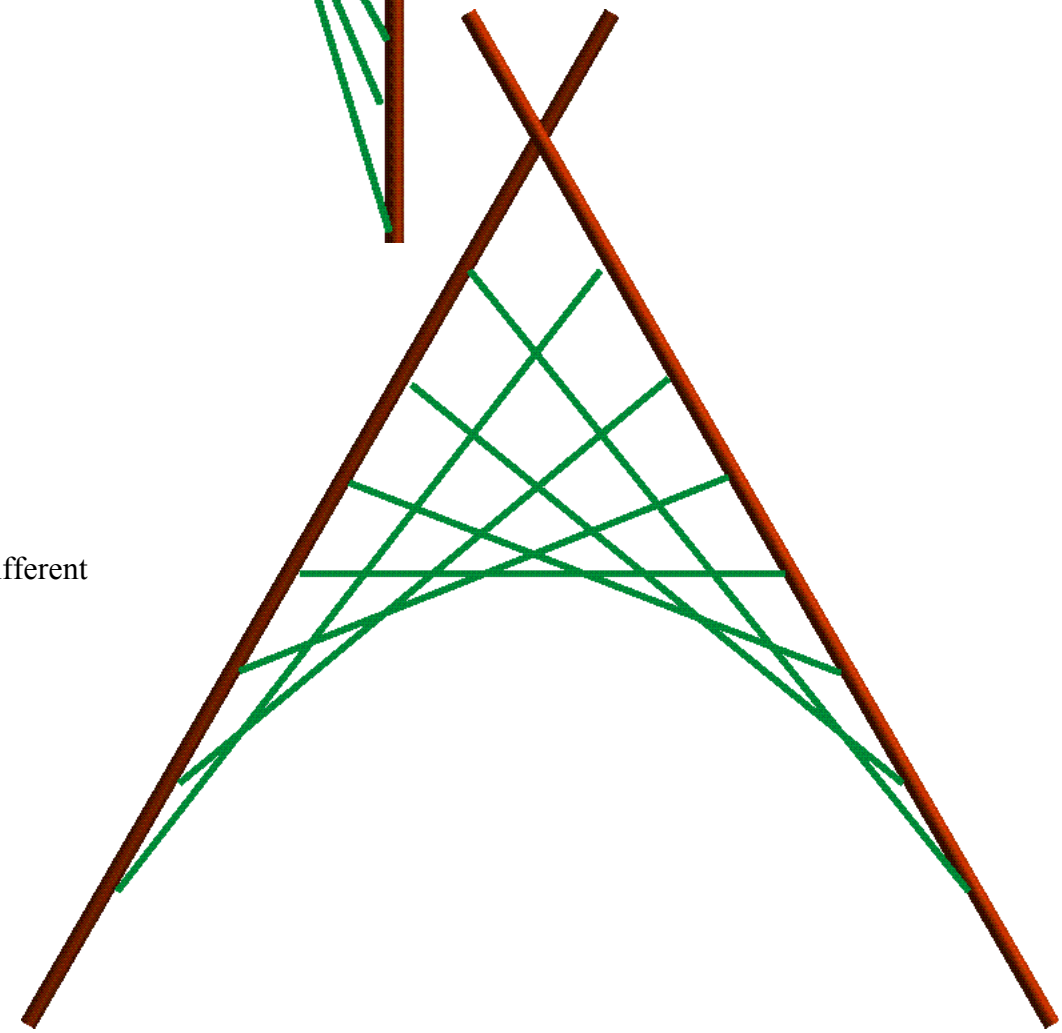


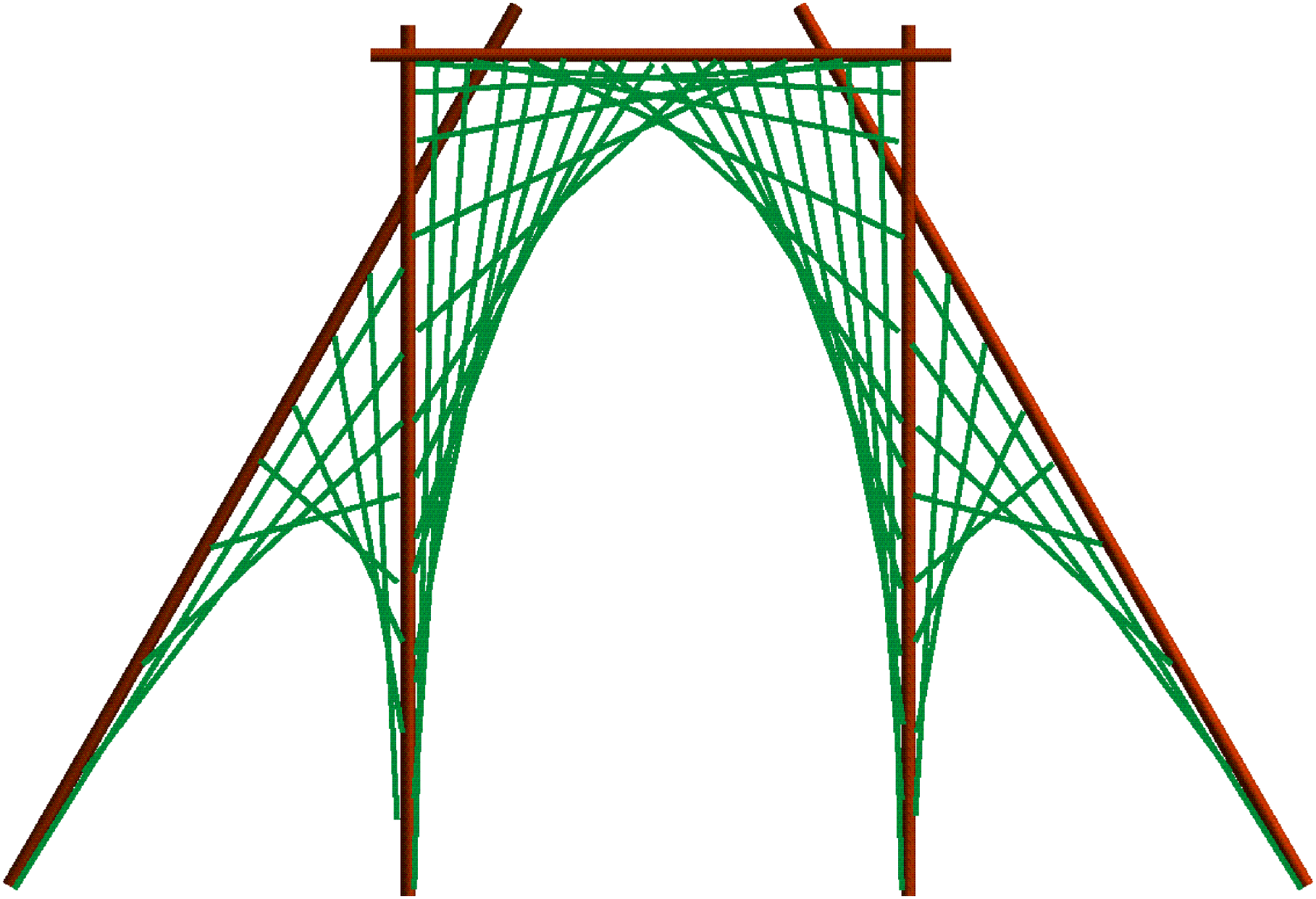
Here's another way to make the gateway. Begin at the bottom of one upright, but instead of going to the first mark on the cross-bar, go to the middle of the cross-bar. Work your way up the upright and over towards the far corner of the crossbar. Do the same on the other upright spar.



You can make this fancier by adding more rope, beginning at the center of the cross-bar and working your way down the two uprights.

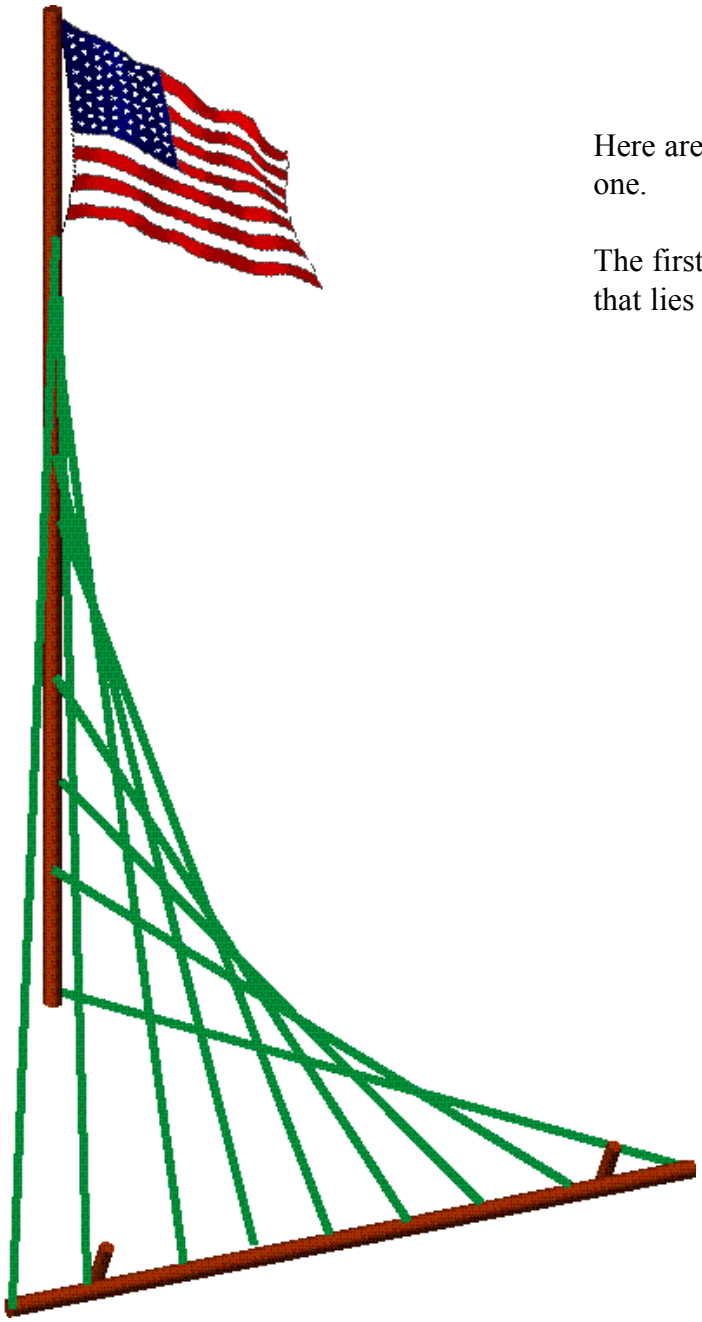
Here's a gateway using a different shaped arch frame.





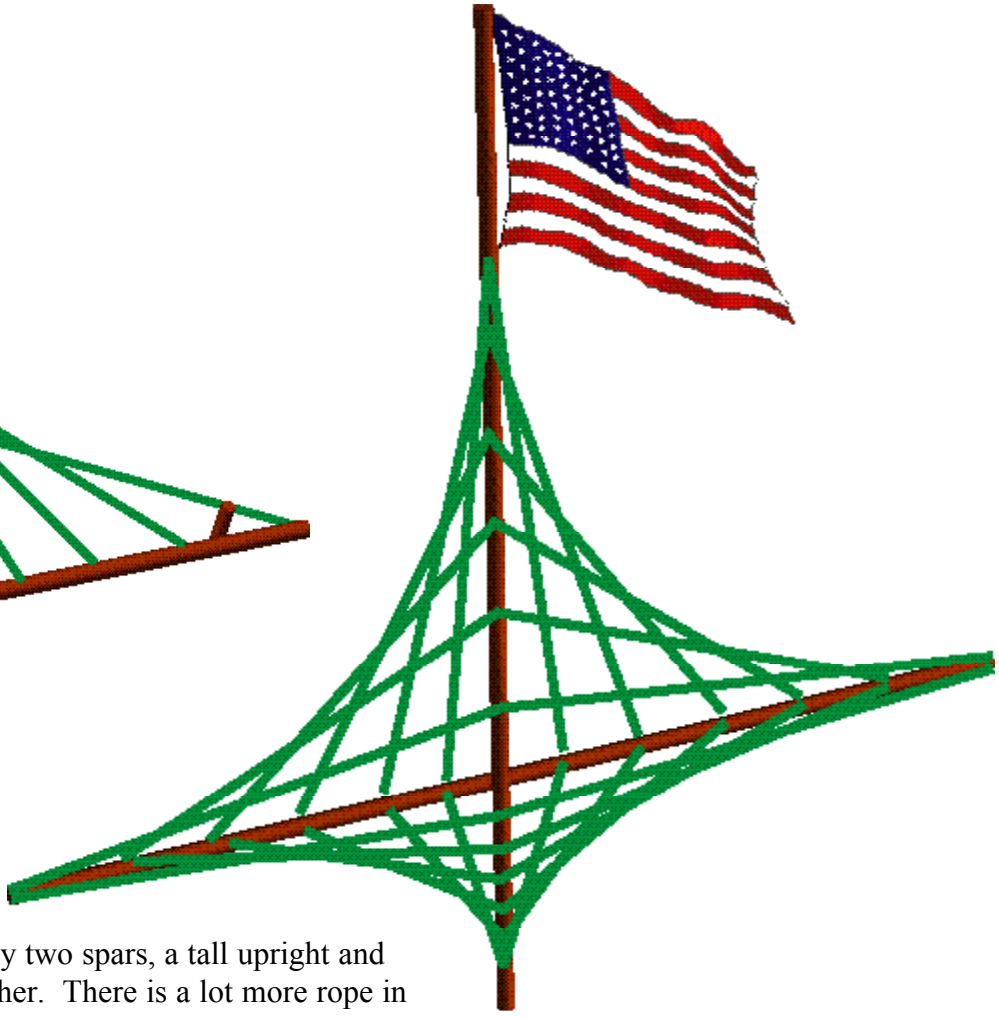
And here’s a very fancy gateway made by combining three separate forms.

Flagpoles

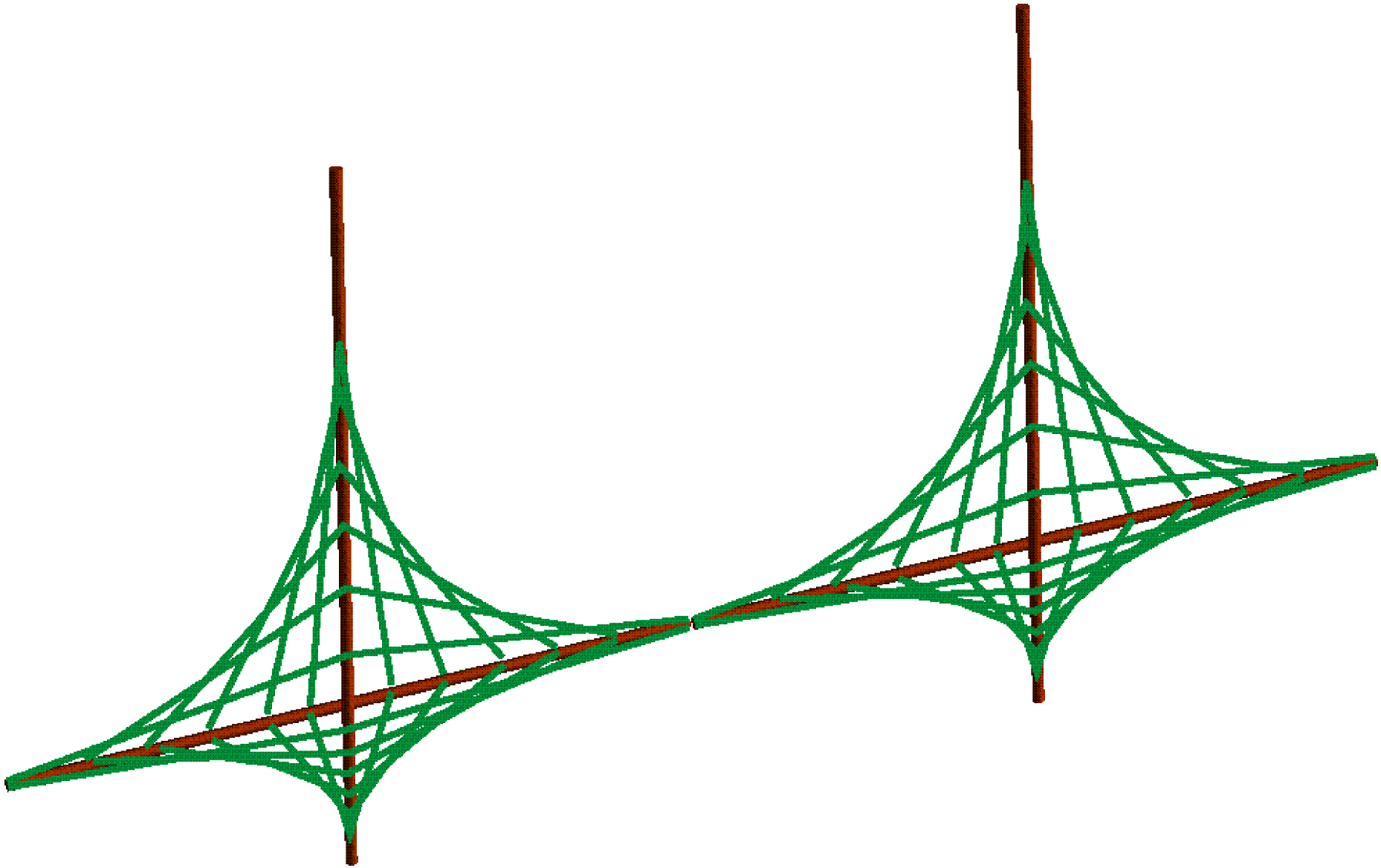


Here are three flagpoles, each one fancier than the previous one.

The first has only two spars -- a long upright and a short one that lies on the ground, held in place by two stakes.



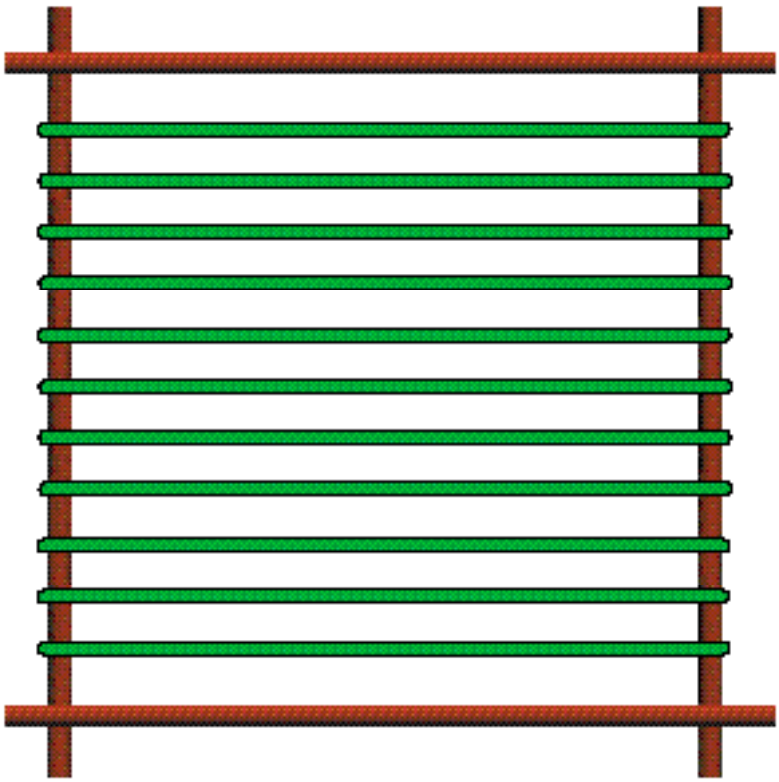
The second flagpole also has only two spars, a tall upright and a shorter cross-spar, lashed together. There is a lot more rope in this flagpole.

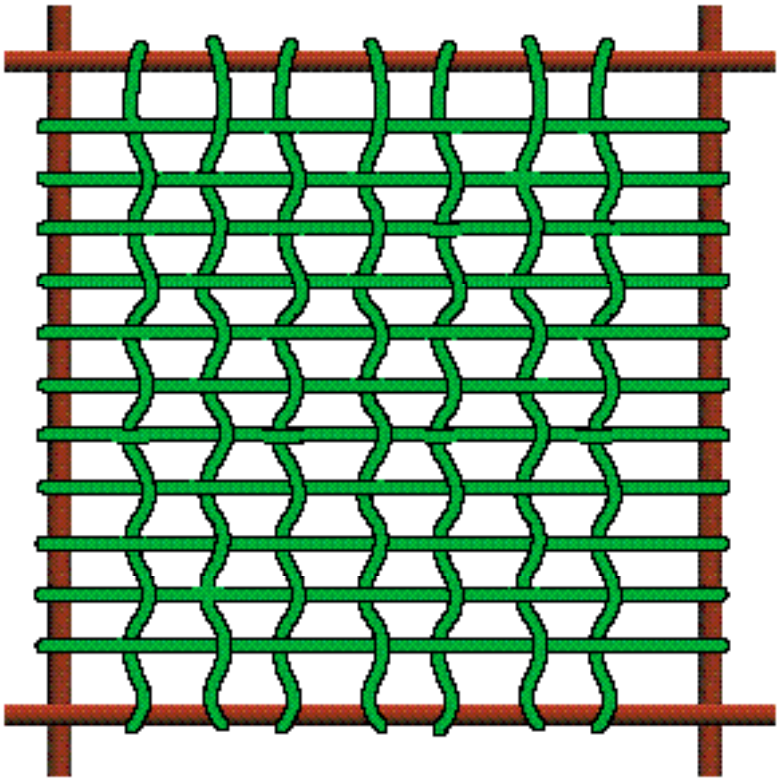


The third flagpole is the fanciest. It is basically like the previous one, except that there are two tall upright spars and a third long spar lashed across both. Actually there is no limit to the number of uprights you can have. Make as many as you need to hold the number of flags you want to fly. If you are planning on using an American flag, however, with two or more uprights, make sure that the upright on the left (as you are looking at it) is taller. If you are using three uprights, you should make the center one taller and put the American flag there.

Lattice Work

There are a number of structures you can make using a basic “lattice” form. Begin by lashing four long spars together in a frame. Then tie ropes across evenly spaced.

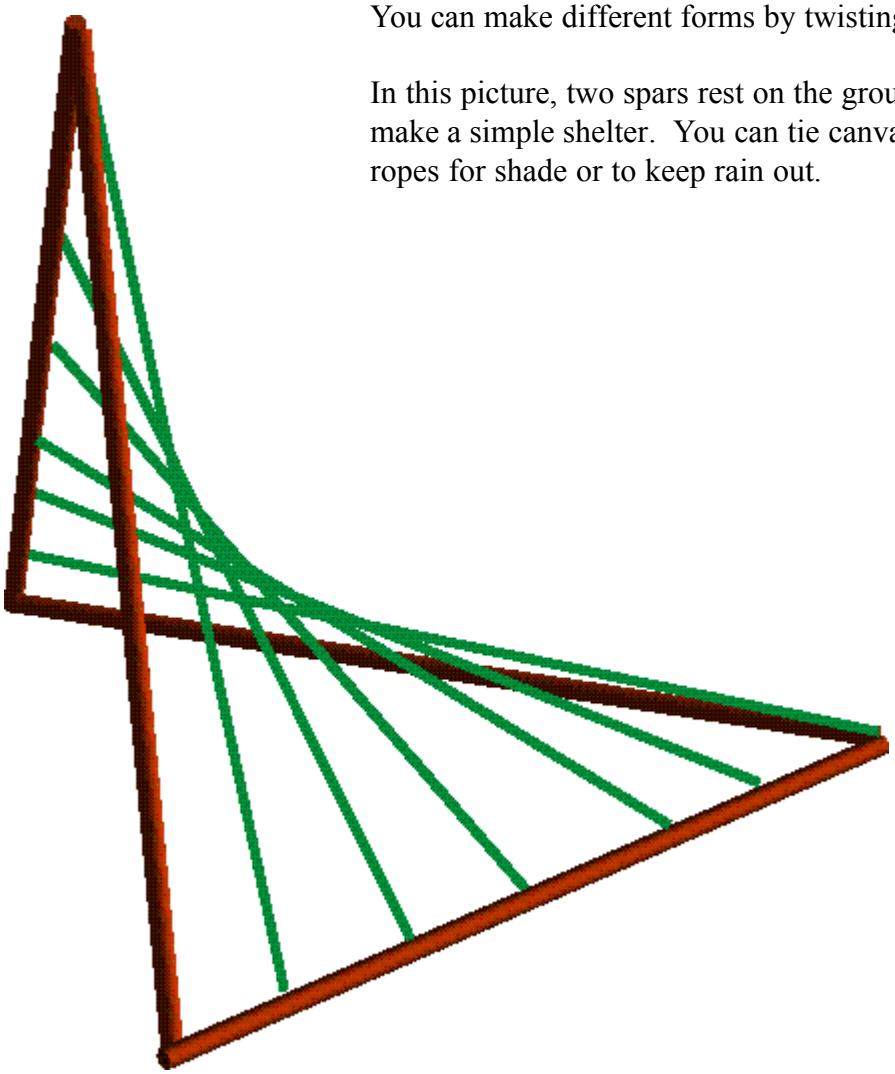


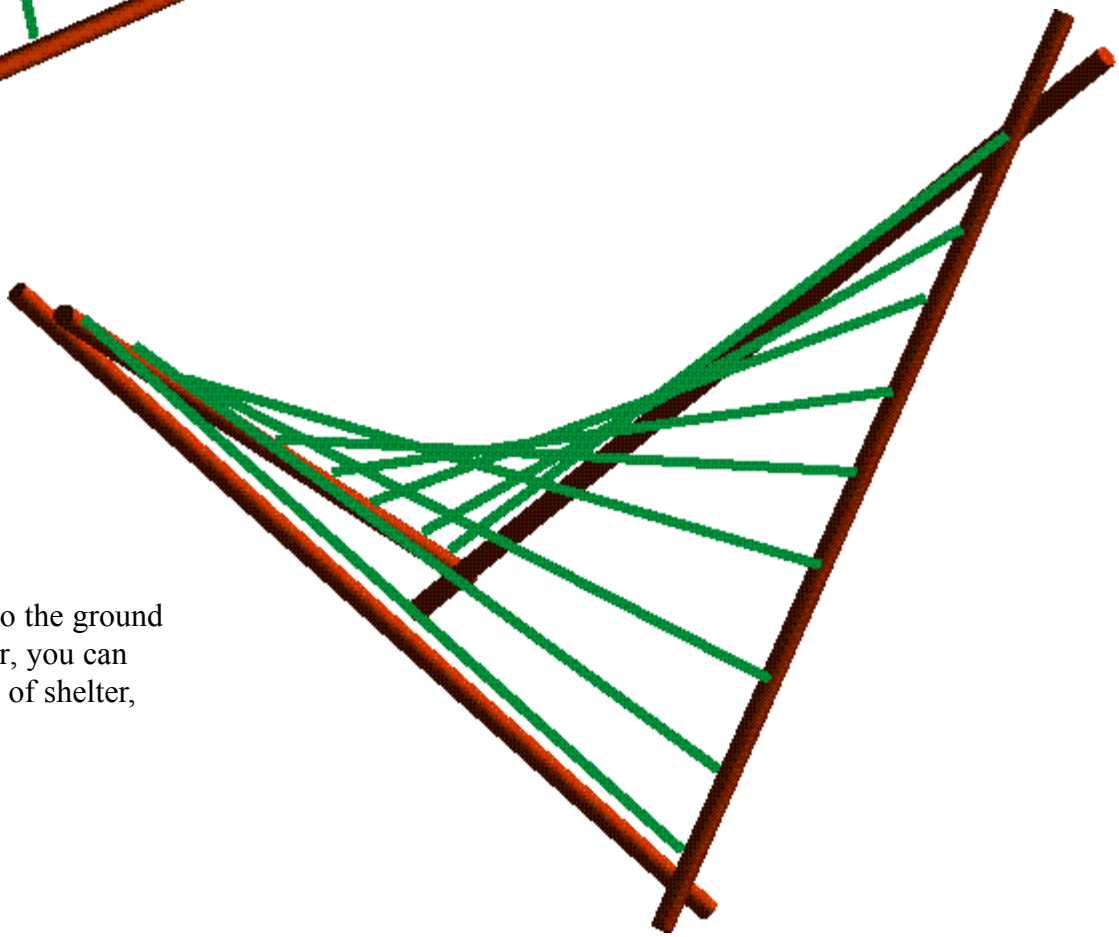


Then tie ropes across the other way, weaving them over and under the first set as you go.

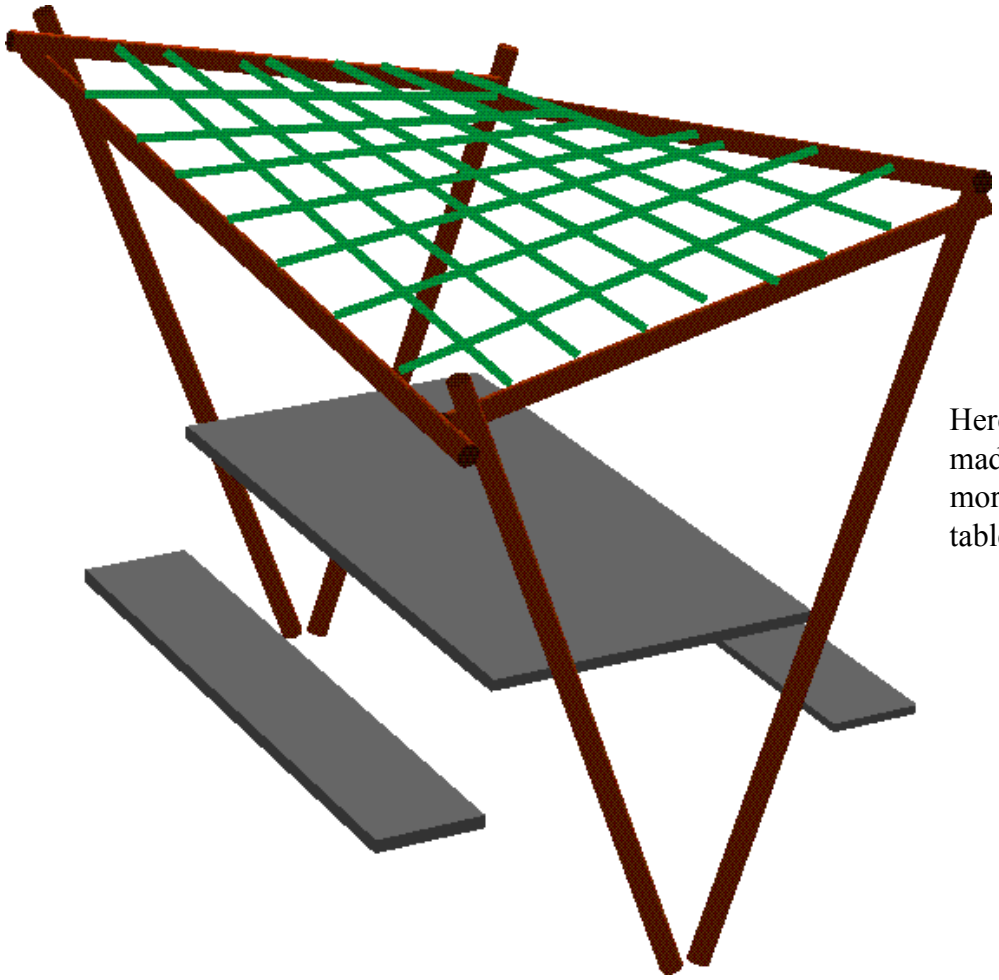
You can make different forms by twisting the spars into various positions.

In this picture, two spars rest on the ground and two form an upright arch to make a simple shelter. You can tie canvas, palm fronds or boughs on the ropes for shade or to keep rain out.





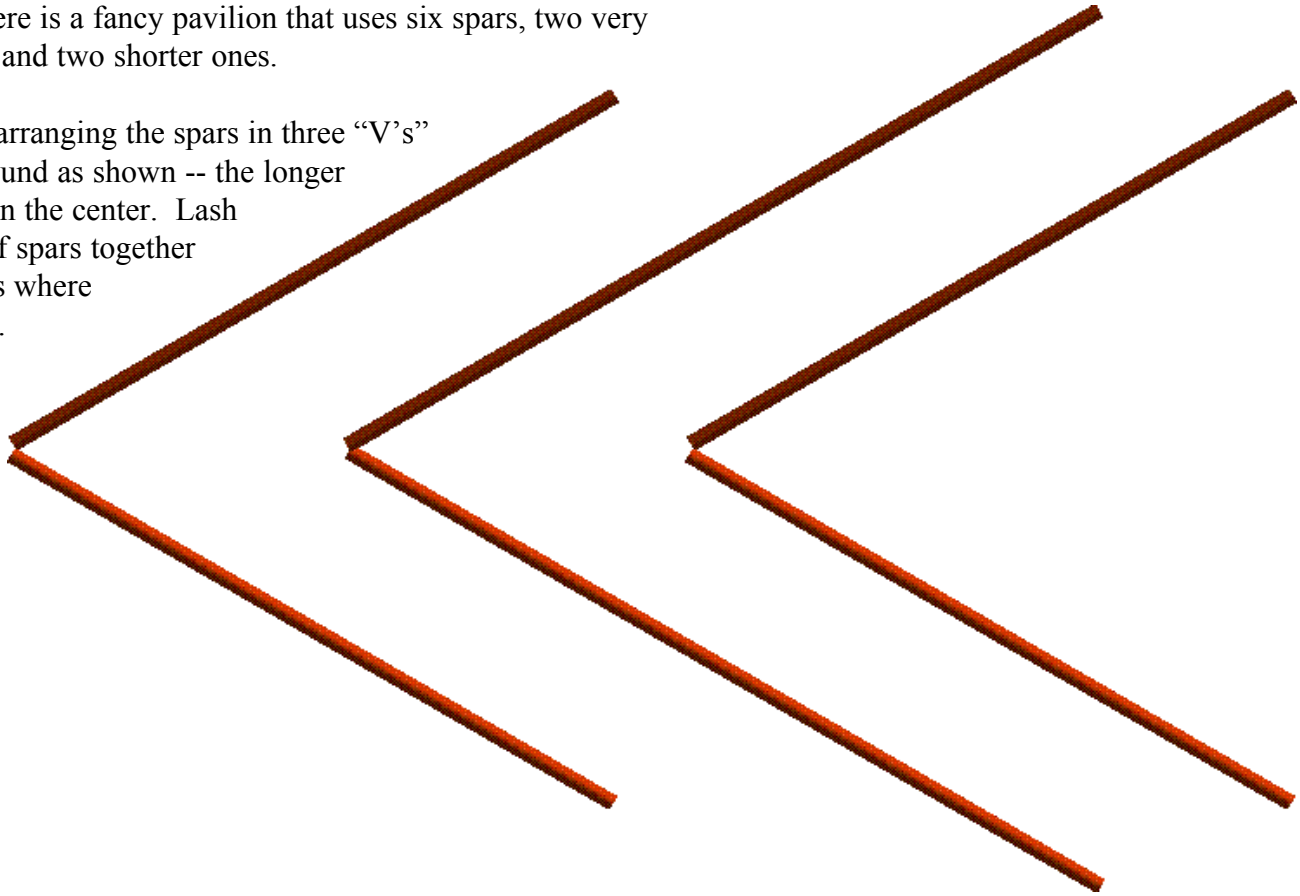
By driving the spars into the ground where they join together, you can make a more open kind of shelter, called a pavilion.



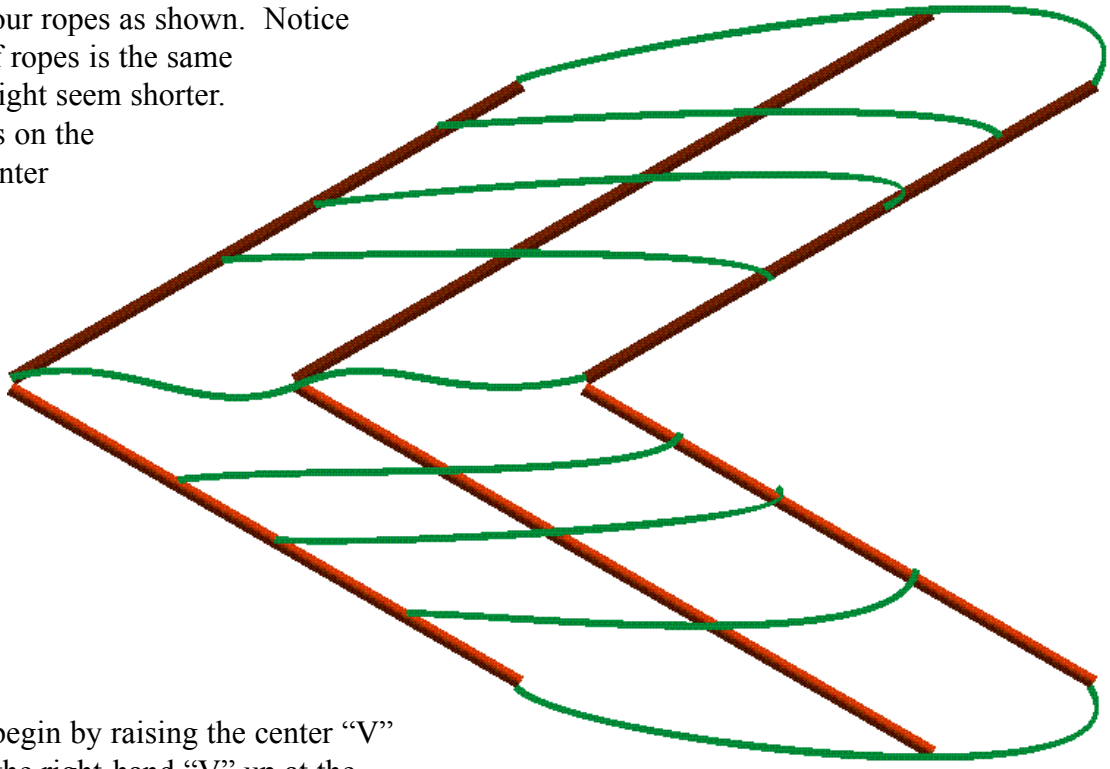
Here is a roof for a picnic table made by lashing your lattice to four more spars that are attached to the table as shown.

Finally, here is a fancy pavilion that uses six spars, two very long ones and two shorter ones.

Begin by arranging the spars in three “V’s” on the ground as shown -- the longer spars are in the center. Lash each set of spars together at the ends where they cross.



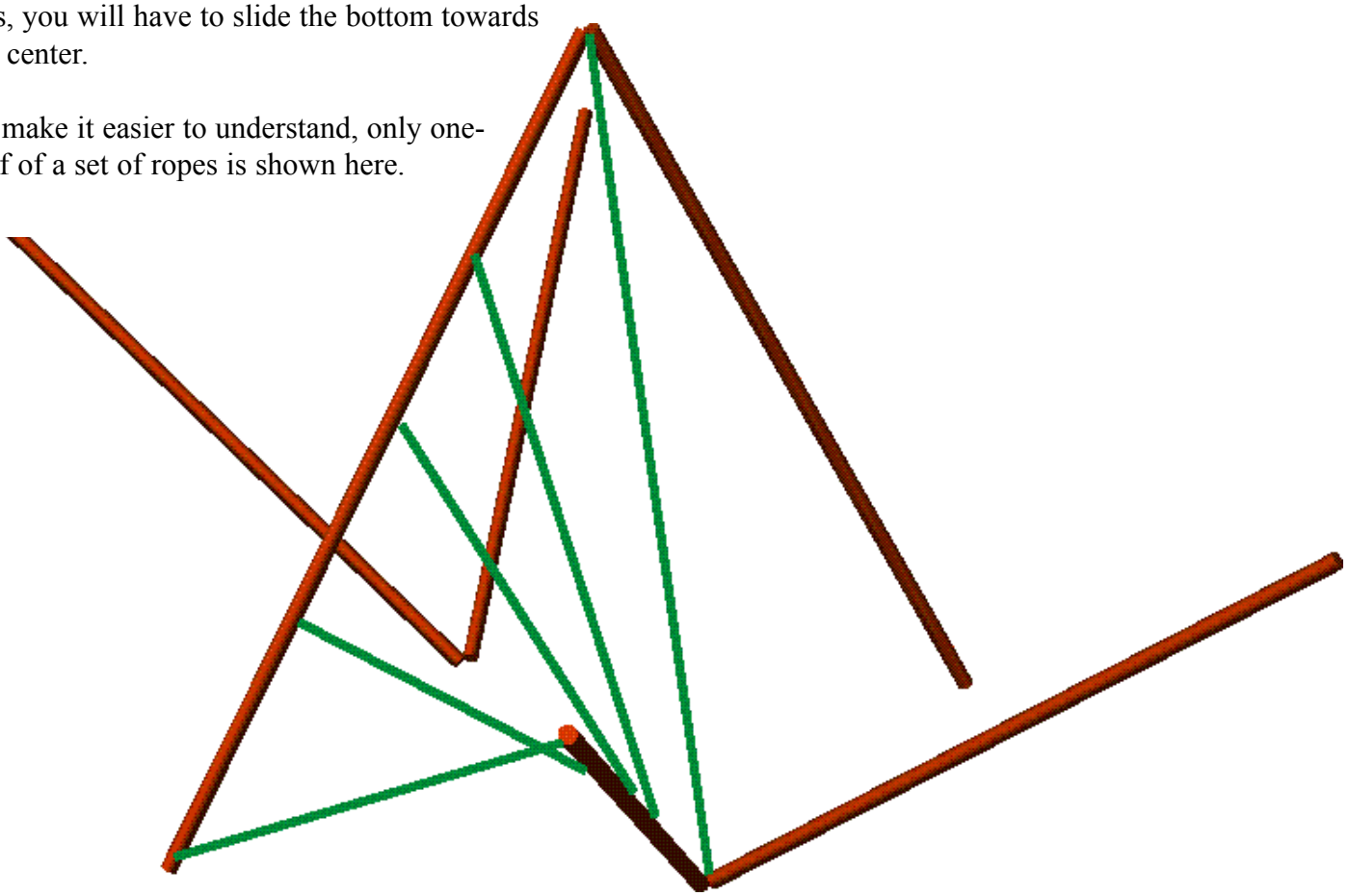
The next step is to tie your ropes as shown. Notice that although each set of ropes is the same length, the ones on the right seem shorter. This is because the spars on the right are closer to the center than those on the left. Also the ropes are not stretched tight.

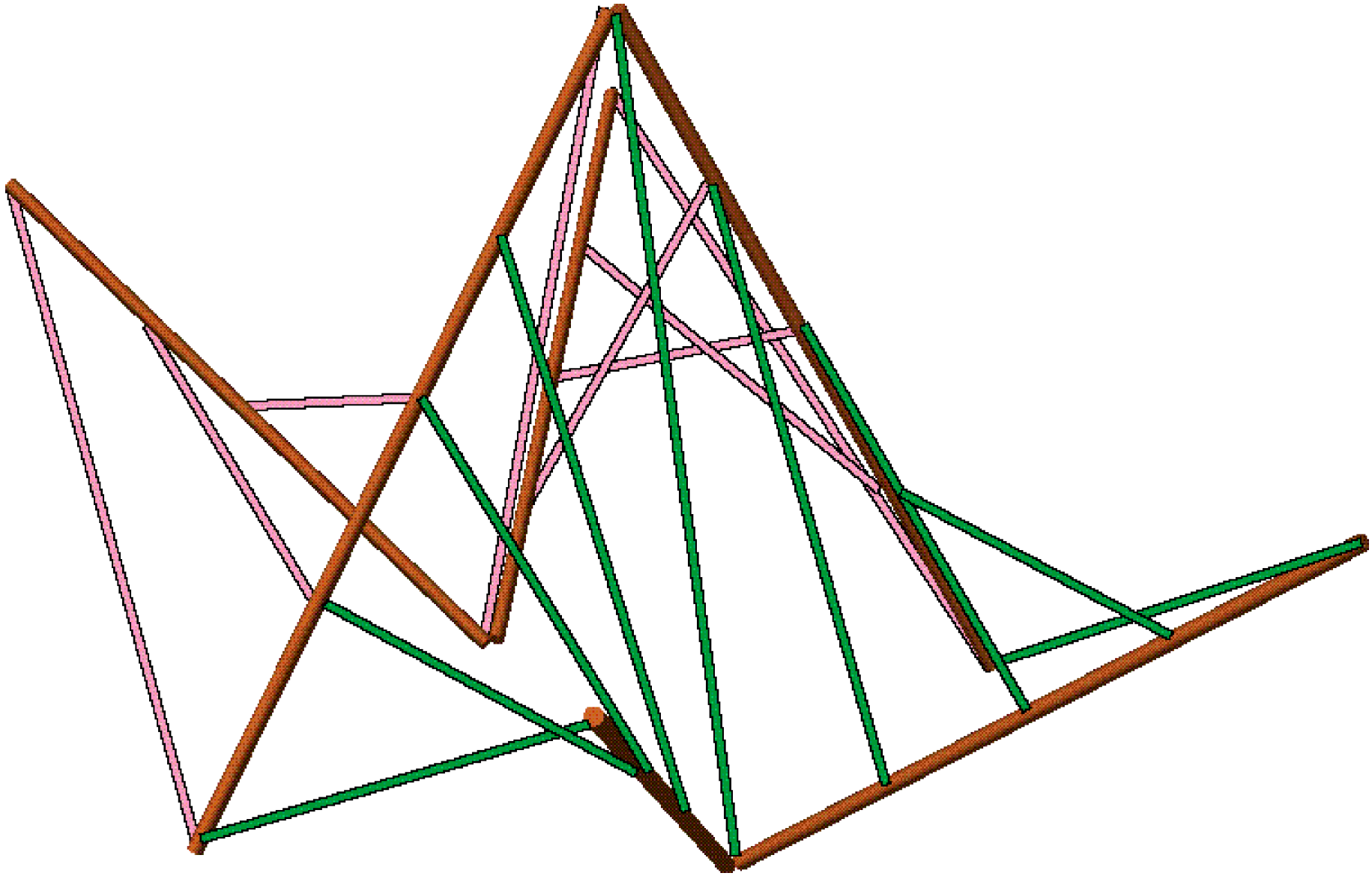


To set the structure up, begin by raising the center "V" on its legs. Then stand the right-hand "V" up at the point where it is lashed together.

Finally set the left-hand "V" up on end. To do this, you will have to slide the bottom towards the center.

To make it easier to understand, only one-half of a set of ropes is shown here.





The finished pavilion will look like this.

CHAPTER IX
TOWERS

Towers are fun to build. You can use them for flags or lights, and you even can climb on them. But you must be careful. They cannot be too tall and they must be very strong!

Flagpole

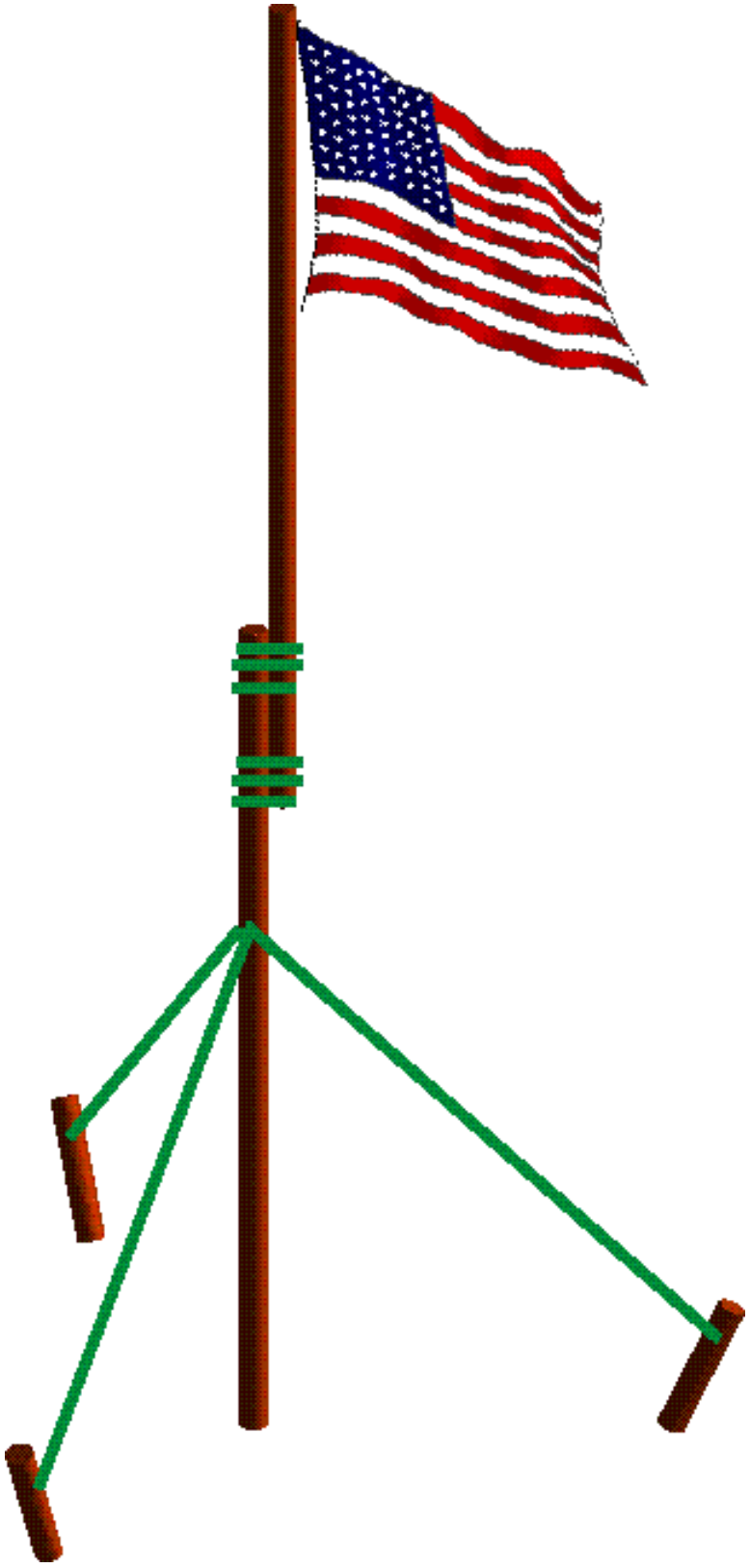
Let's begin with the simplest tower of all -- a flagpole!

All you need are two or more long spars, tied together using round lashings. If you won't need to raise or lower the flag, you can tie it onto the top spar before raising the pole. Otherwise, you can use a simple pulley.

Once the spars are lashed together, place the bottom in a hole you have dug and brace the upright pole(s) using three ropes from the pole(s) to stakes you have driven into the ground.

That's all there is to it!

An American flag is shown here, but you can make your own flag with anything you want on it to fly on your flagpole.

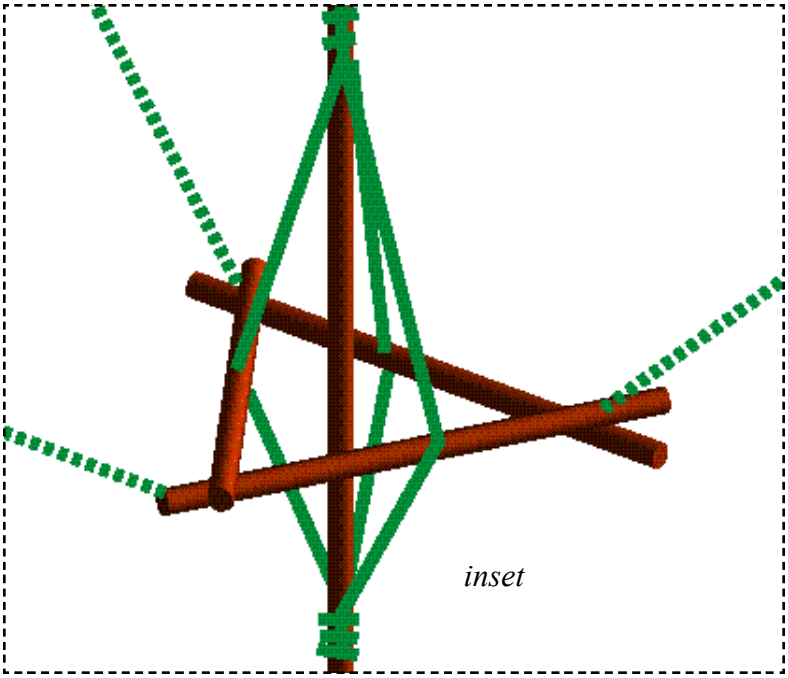


Flagpole with Base

Let's say that, for some reason, you cannot drive a stake into the ground. Maybe the soil is too sandy, and the stake won't "hold." Maybe the ground is too rocky. You still can have your flagpole by making this simple base.

Balancing Flagpole

Courtesy of John Mensing and Jim Jaeger

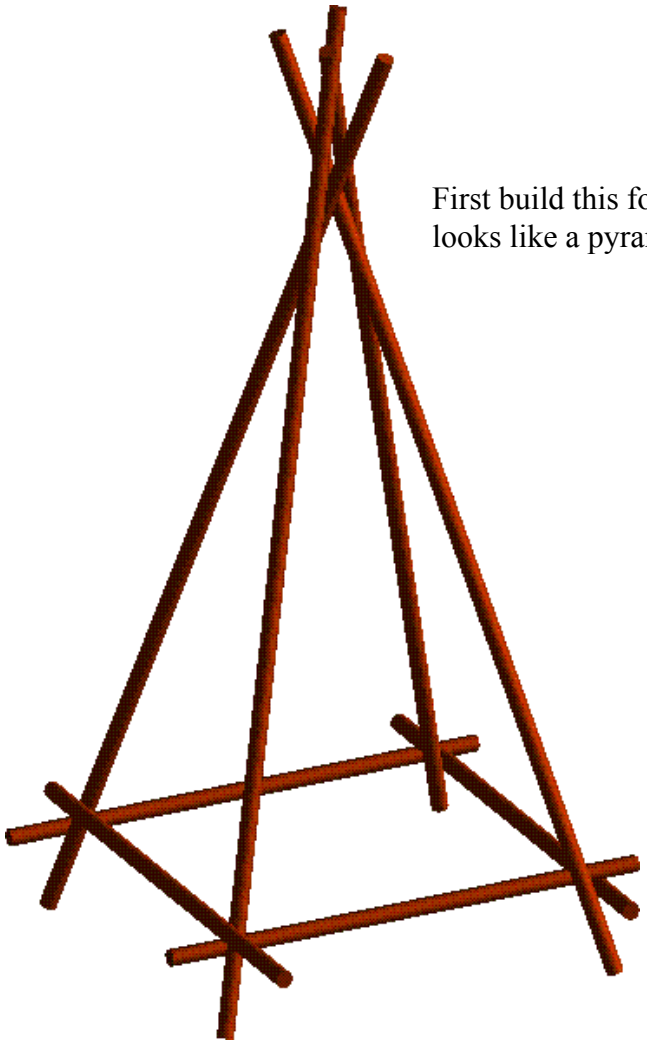


back support braces not shown

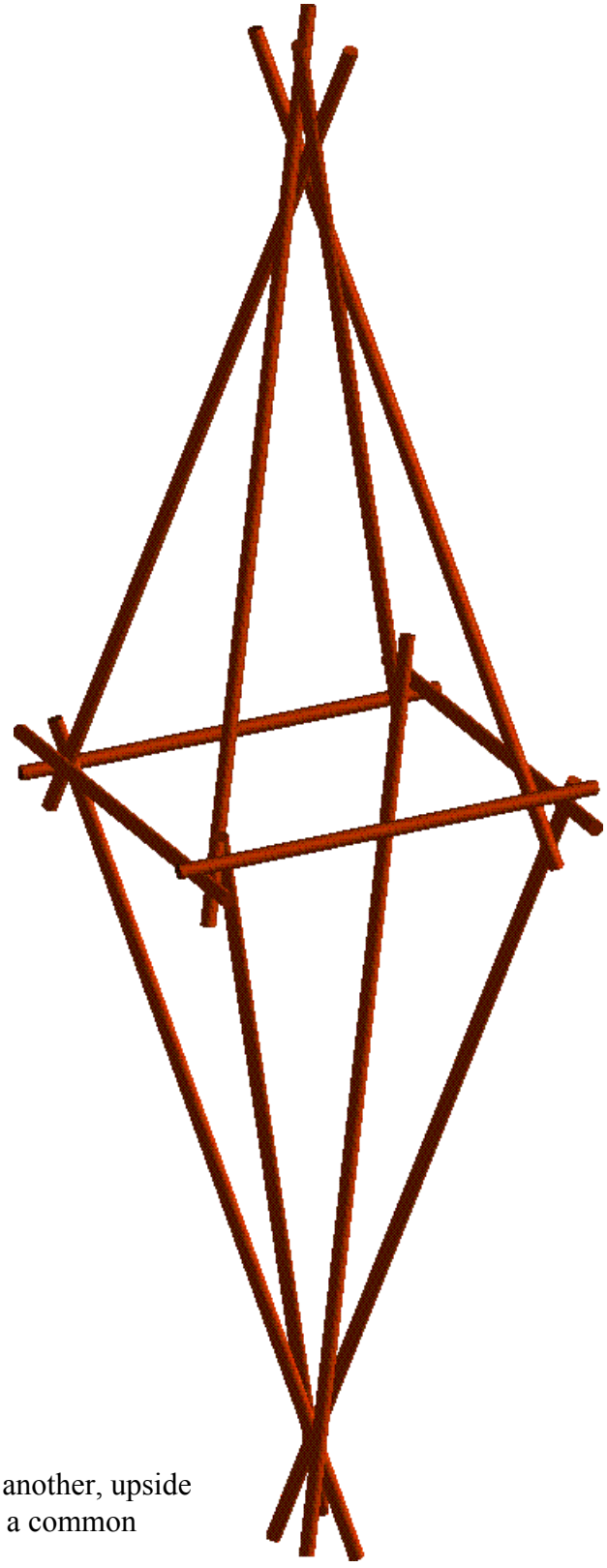
The Balancing Flagpole's central shaft does not touch the ground. It uses a double suspension system. The central shaft is suspended in the triangle (see inset) and the inner structure is again suspended from three side shafts.

Skylon Weathercock

Instead of a flag, you could make a weather vane to put on your flagpole. But it would be hard to hang a light from it. Here's a tower that can be used for either.

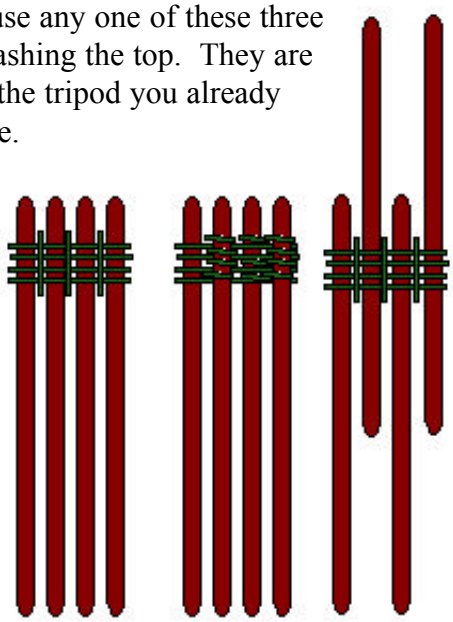


First build this form. It looks like a pyramid.



Then build another, upside down, with a common base.

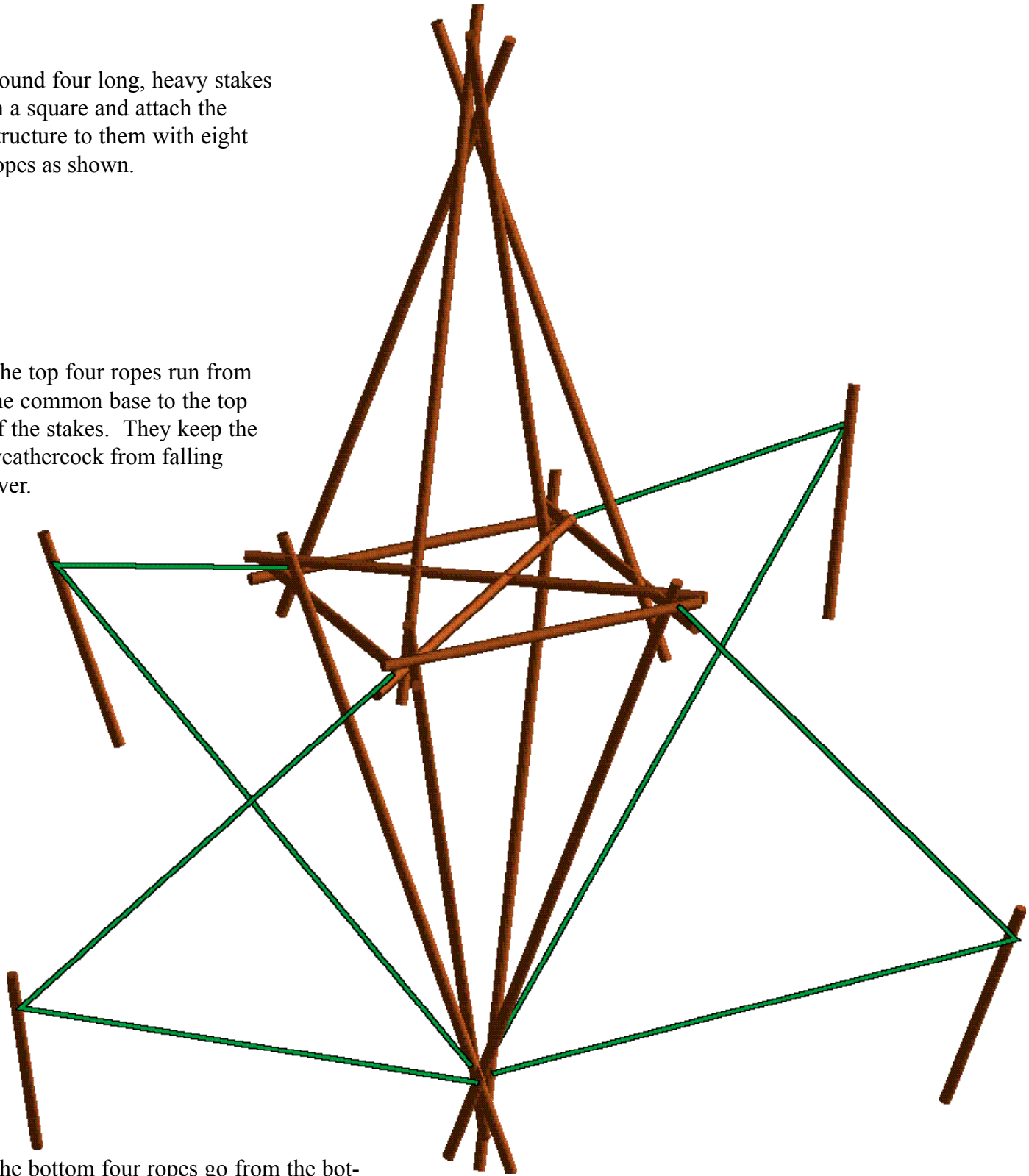
You can use any one of these three ways of lashing the top. They are based on the tripod you already have made.



Add cross-pieces to the common base to make the form stable and a small spar at the top to hold your weather vane (not shown).

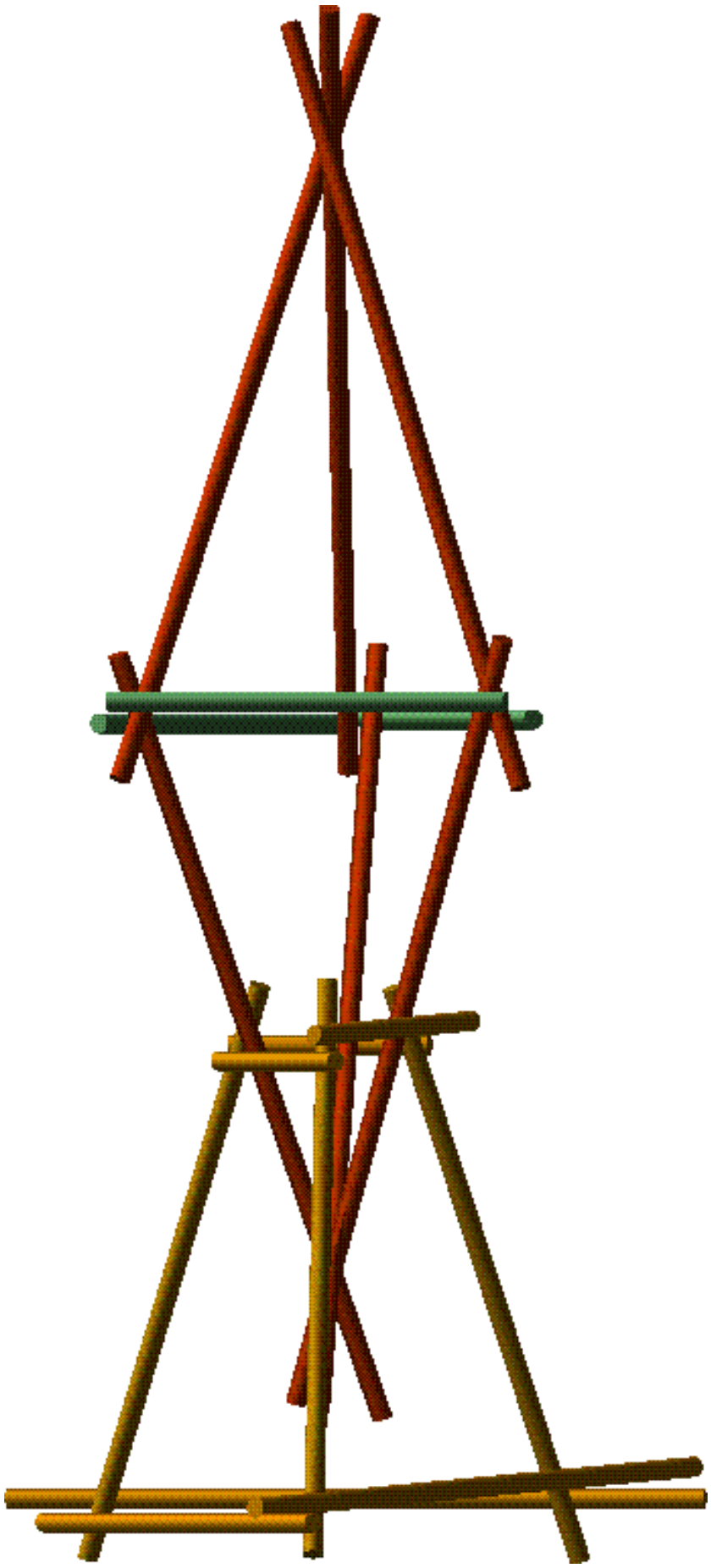
Pound four long, heavy stakes in a square and attach the structure to them with eight ropes as shown.

The top four ropes run from the common base to the top of the stakes. They keep the weathercock from falling over.



The bottom four ropes go from the bottom of the structure to the top of the stakes. When pulled very tight, they will lift the weathercock off the ground and it will seem to float in the air!

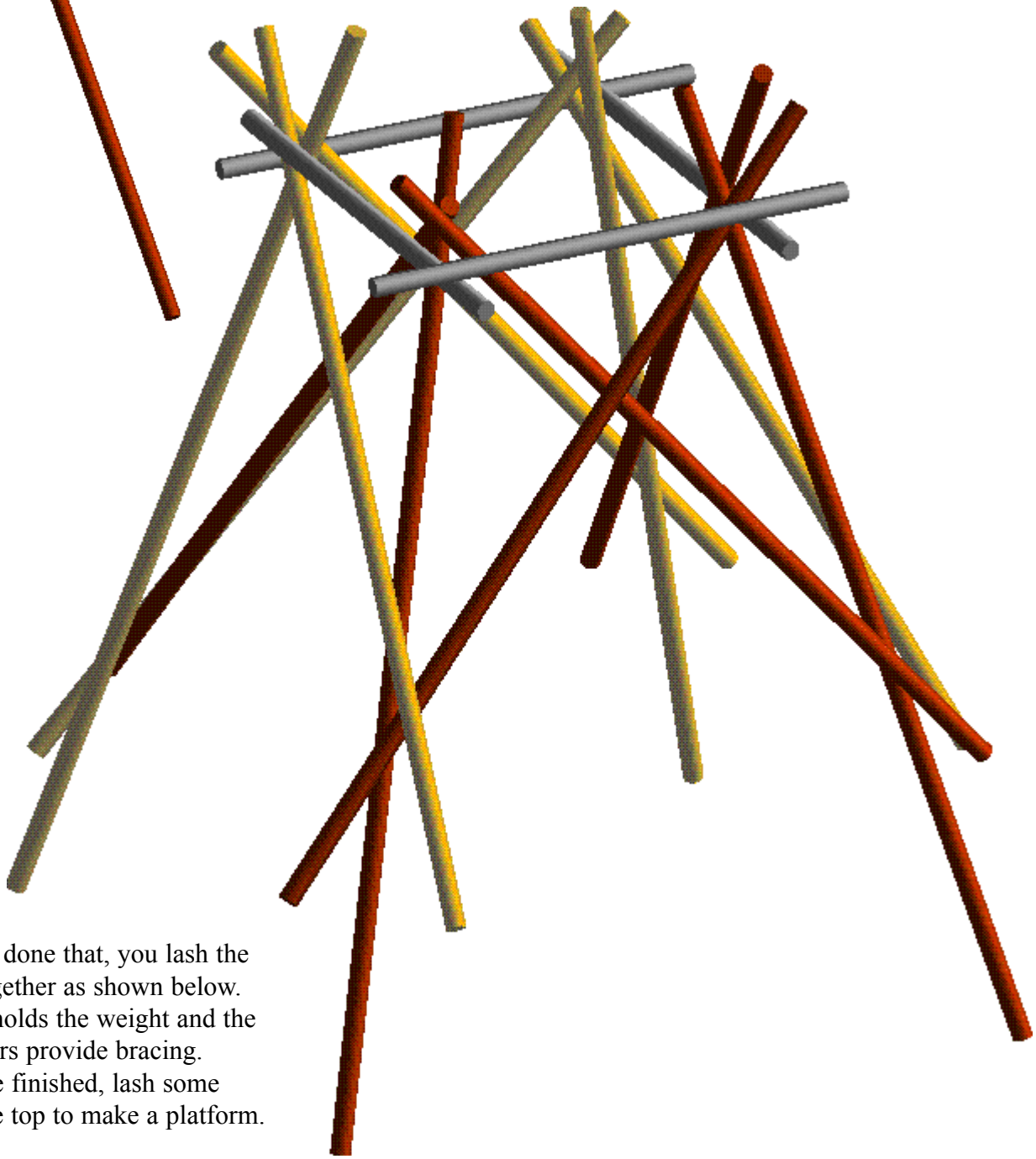
Like the Balancing Flagpole, the Skylon Weathercock does not touch the ground.



Here’s another flagpole made from three tripods. Can you see them?

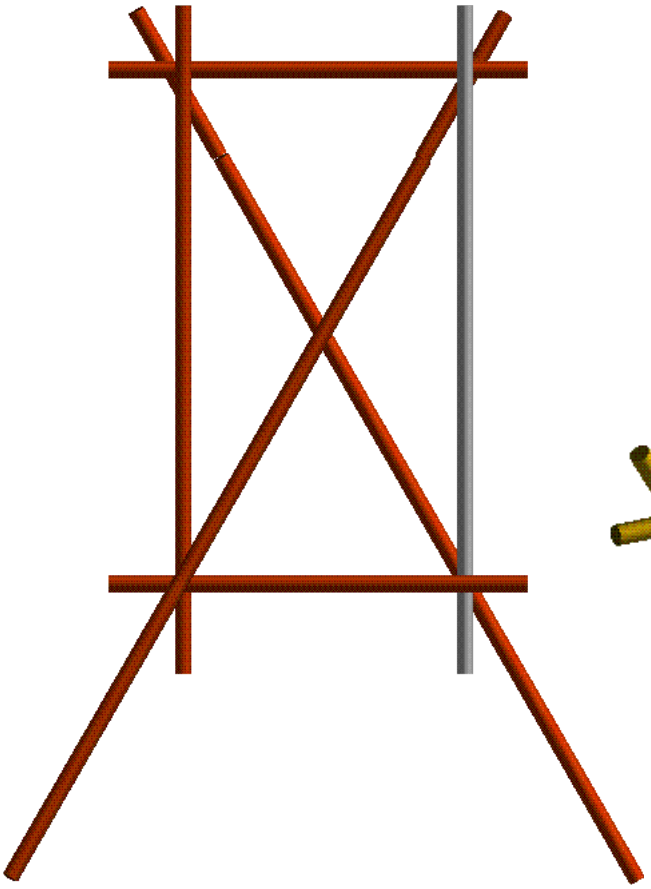
Ten-Minute Tower

Just like its name, the Ten-Minute Tower is quick and easy to build. You start by lashing together four special tripods. The difference is that one leg on each tripod needs to be longer than the other two. If you use two 8-foot spars, the third spar needs to be ten feet long.

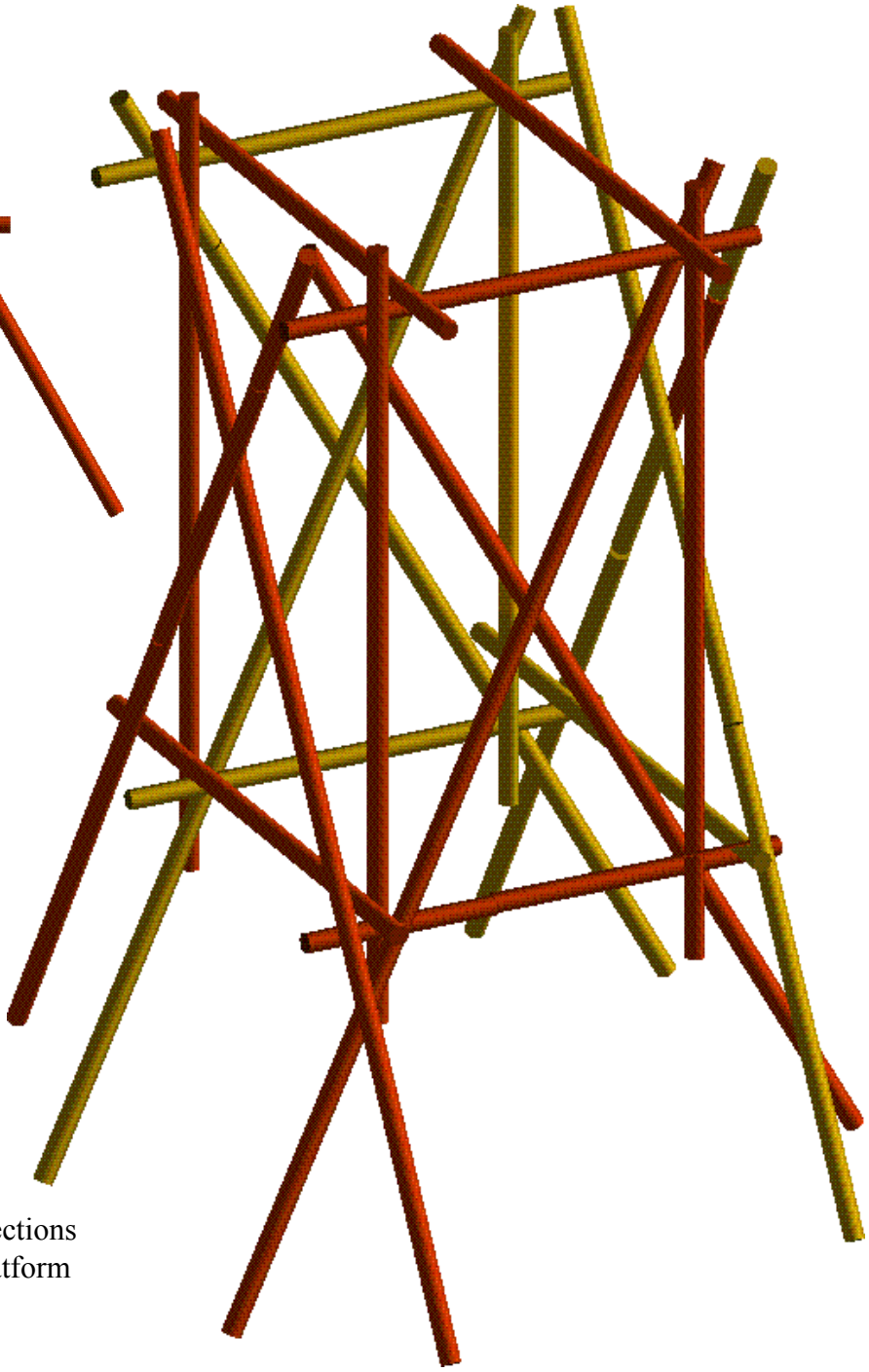


Once you have done that, you lash the four tripods together as shown below. The long spar holds the weight and the two shorter spars provide bracing. When you have finished, lash some spars across the top to make a platform.

Scout Stave Tower

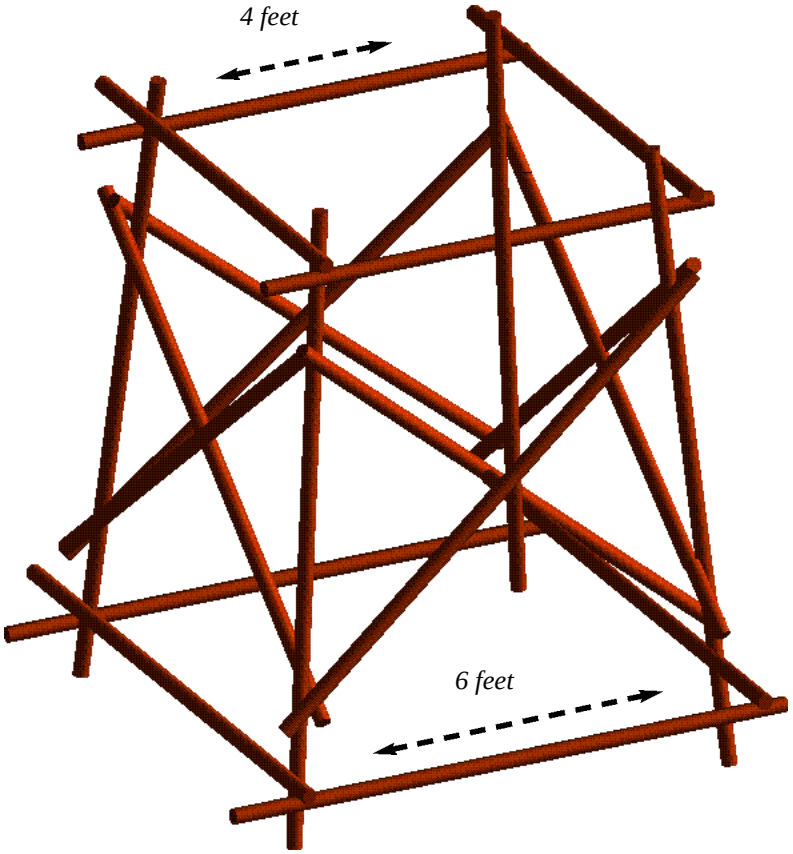


This tower gets its name from the hiking sticks -- or staves -- that are used by Boy Scouts. Begin by making four parts like the one on the left. Notice that one spar is gray. That's because it will be "shared" by two sides.



Complete the tower by lashing the four sections together as shown on the right. Add a platform when you are done.

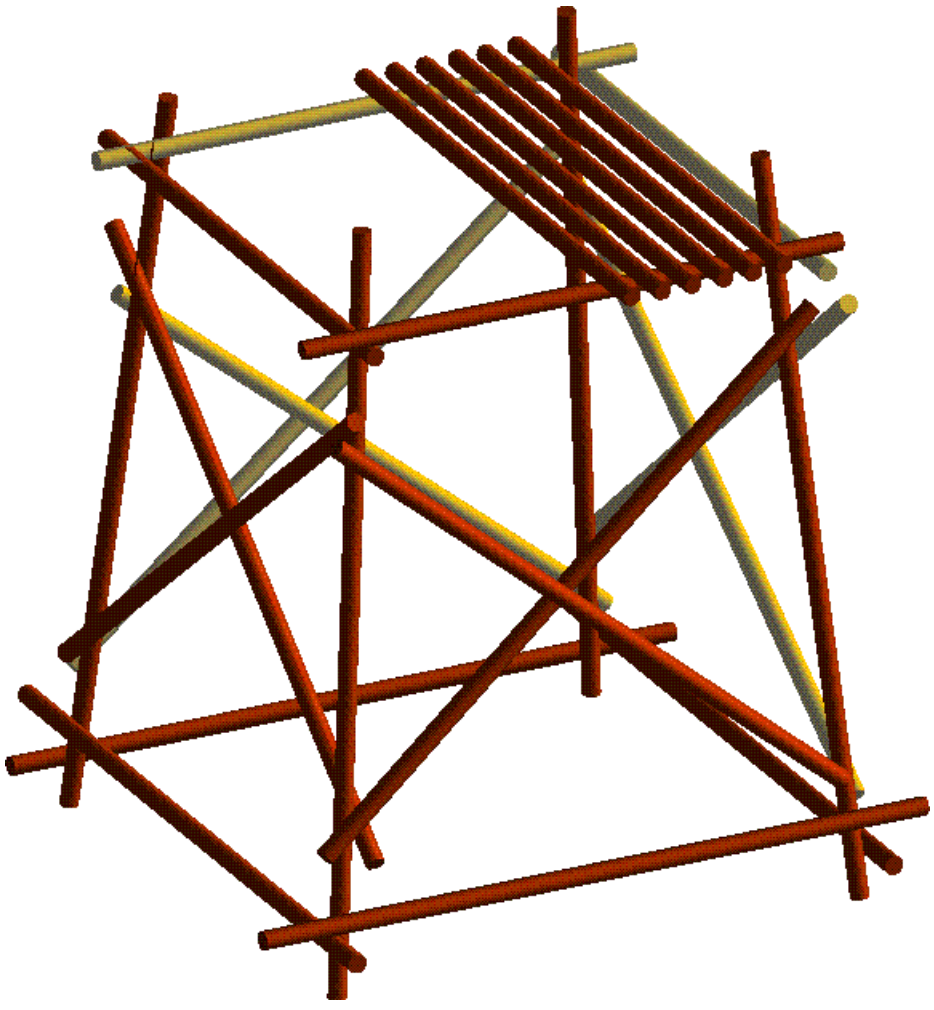
Trestle Tower



The Trestle Tower is formed from four trestles, just like the bases of the Pylon Bridge. To build a 12-foot tower, the legs should be six feet apart at the base and four feet apart at the top.

Once you have completed this "pylon," you can make a platform at the top just as you would build a bridge walkway, by lashing spars closely together across the top cross-pieces. For safety, make the upright spars longer than they need to be and lash a railing around the top (not shown).

To climb up to the platform, make a ladder and lash it to the tower.



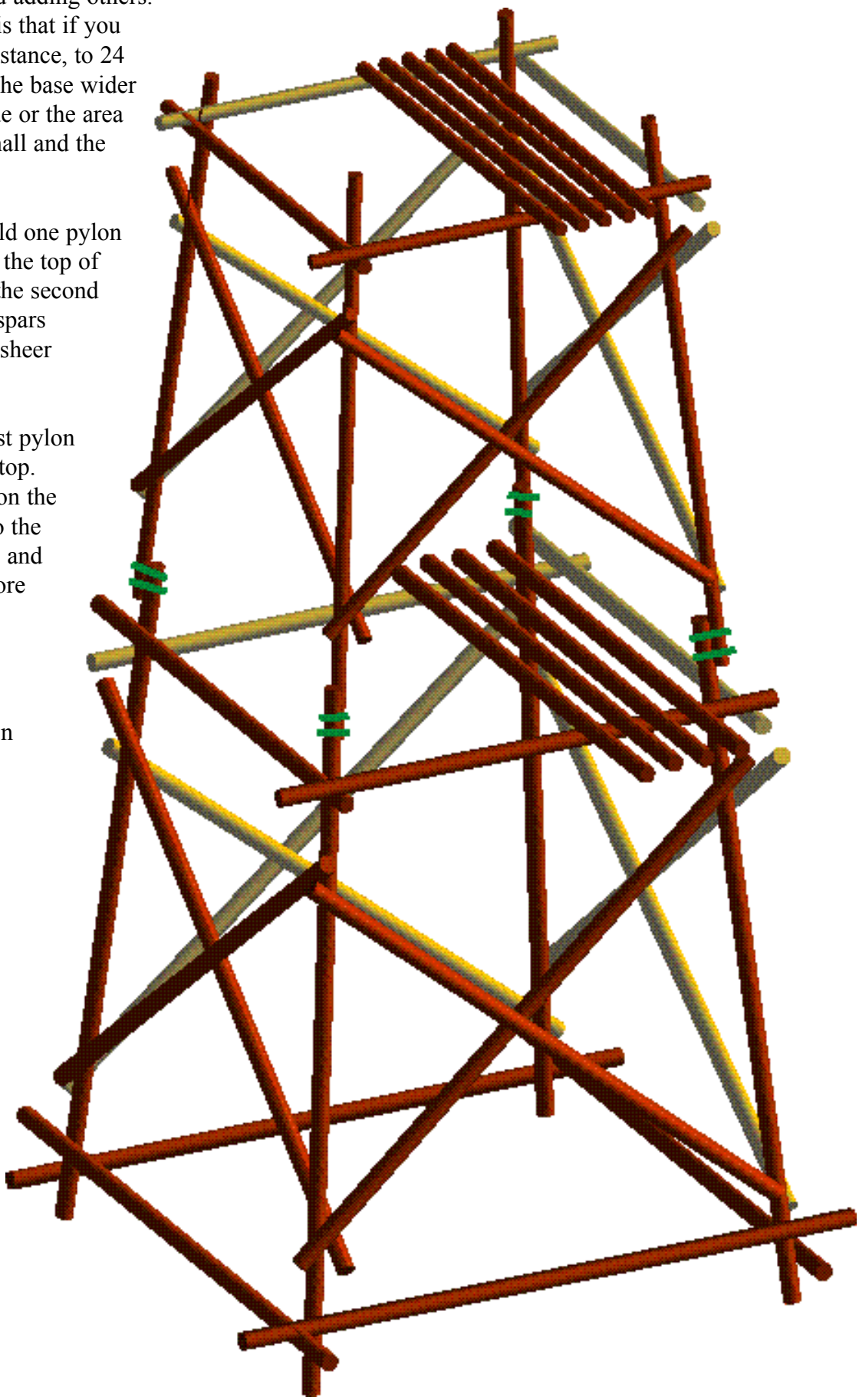
You can make this tower taller by changing some parts and adding others. The thing to remember is that if you double the height, for instance, to 24 feet, you need to make the base wider than six feet on each side or the area at the top will be too small and the tower will not be stable.

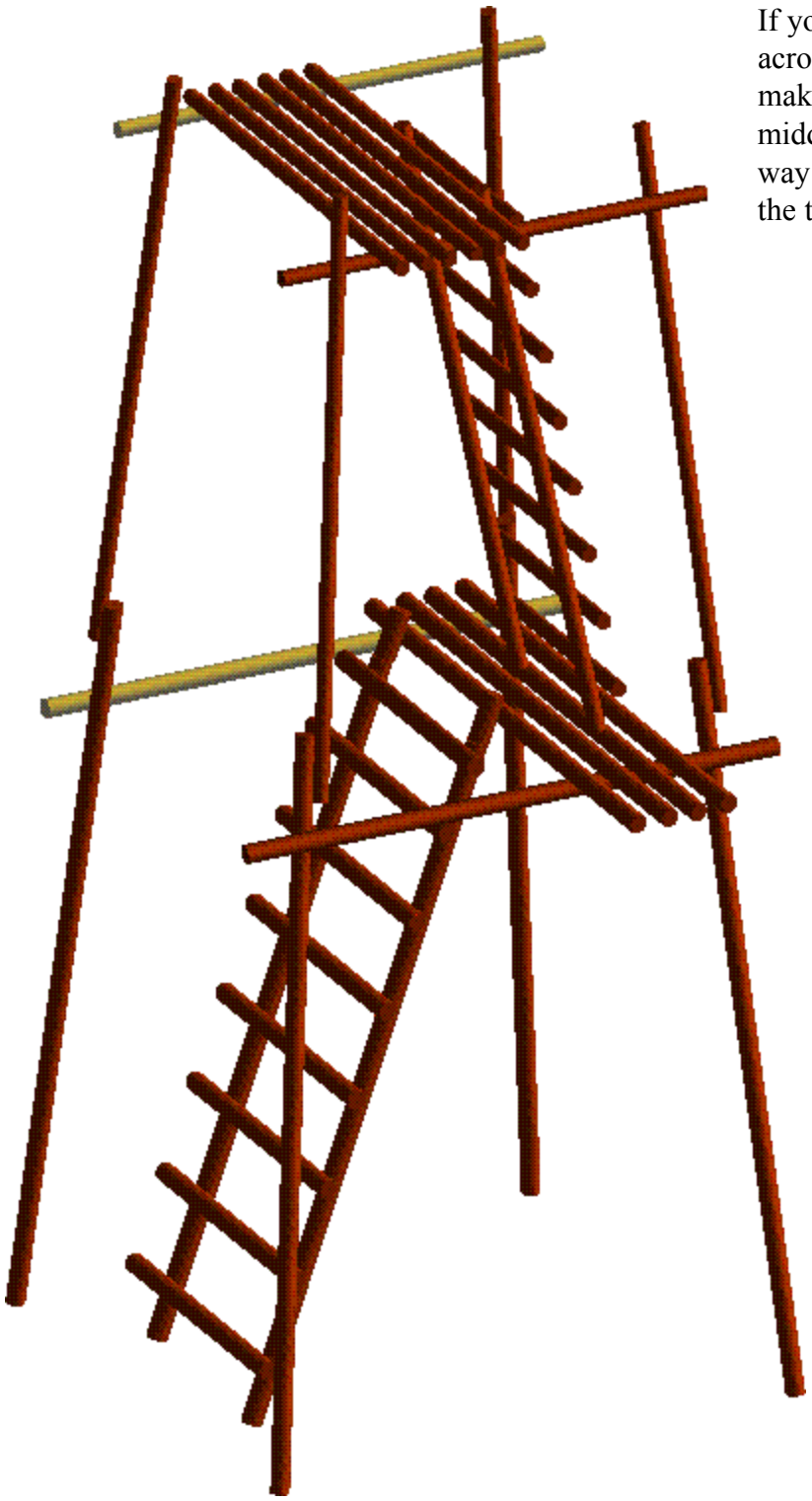
For a 24-foot tower, build one pylon on top of another, using the top of the first as the base for the second and lashing the upright spars together using round or sheer lashings.

Begin by lashing the first pylon with a half-platform on top. Then build two trestles on the ground, hoist them up to the deck, lash them in place and brace them with four more diagonal spars.

Complete the tower by adding two more cross-pieces at the top and then the upper deck.

If you can find four upright spars that are each 24 feet long, you don't have to lash two sets together, but you need to make sure that they are strong enough to support the neces-sary weight. With the longer upright spars, you don't need the middle set of cross pieces or the center platform. But you may want them anyway to make it easier to climb the tower.





Cut-away View

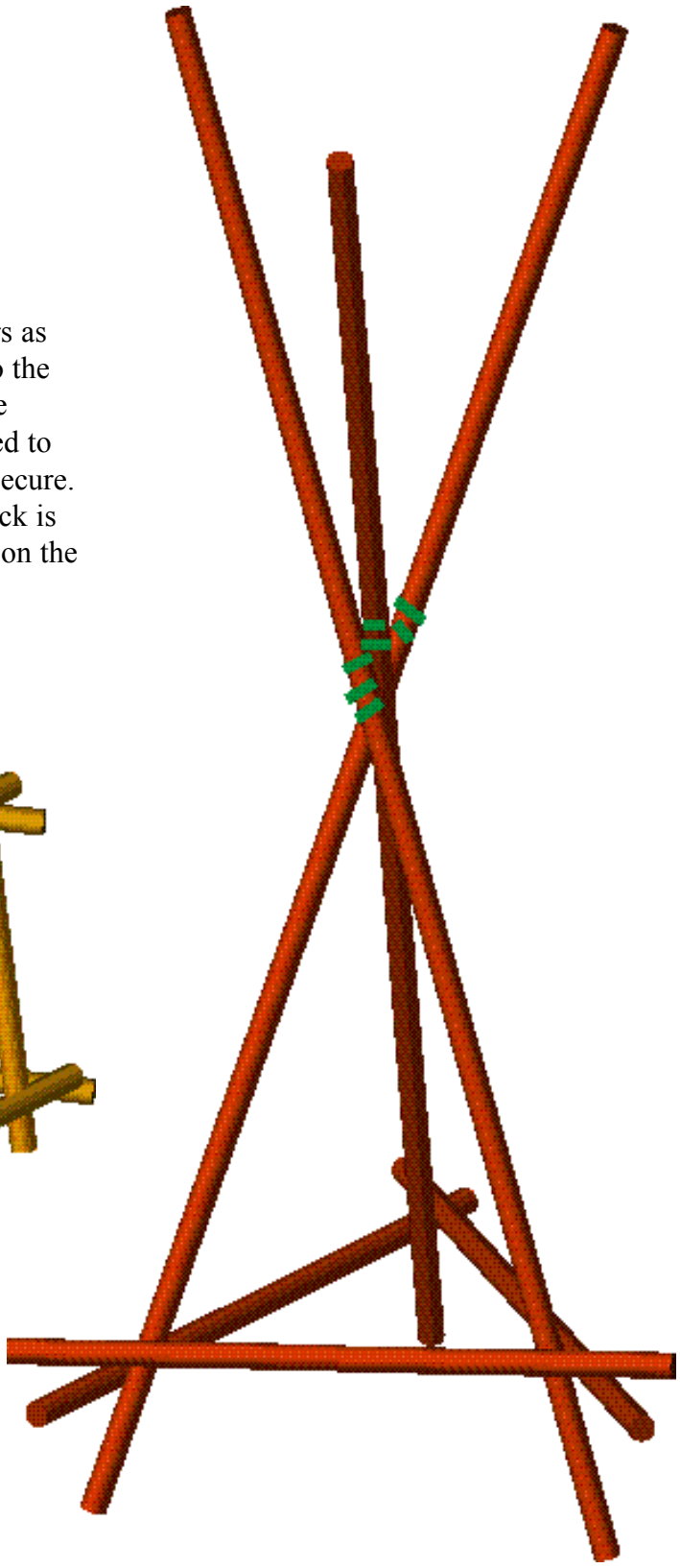
If you build each deck so that it goes only halfway across, and on opposite sides of the tower, you can make two ladders that go from the ground to the middle deck and from there to the top deck. That way you can climb from level to level -- all inside the tower. Be sure to lash the ladders to the decks.

If you think about it, you will see that you could make the tower even taller by adding another "pylon" to the first two. Just remember that the higher the ladder goes, the stronger each spar and lashing must be to support the added weight. Also, the base must be even wider for a 36-foot ladder than for the 24-foot ladder.

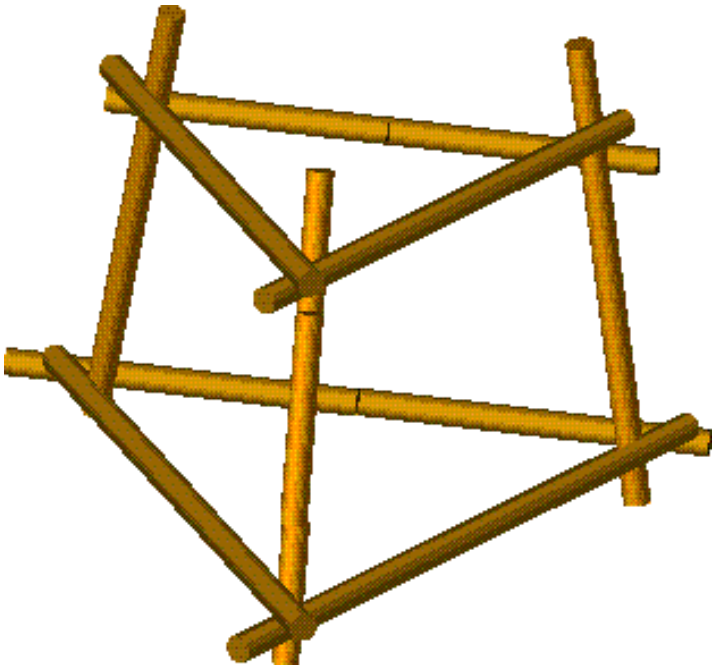
Tower built by author at Camp Strake 1955

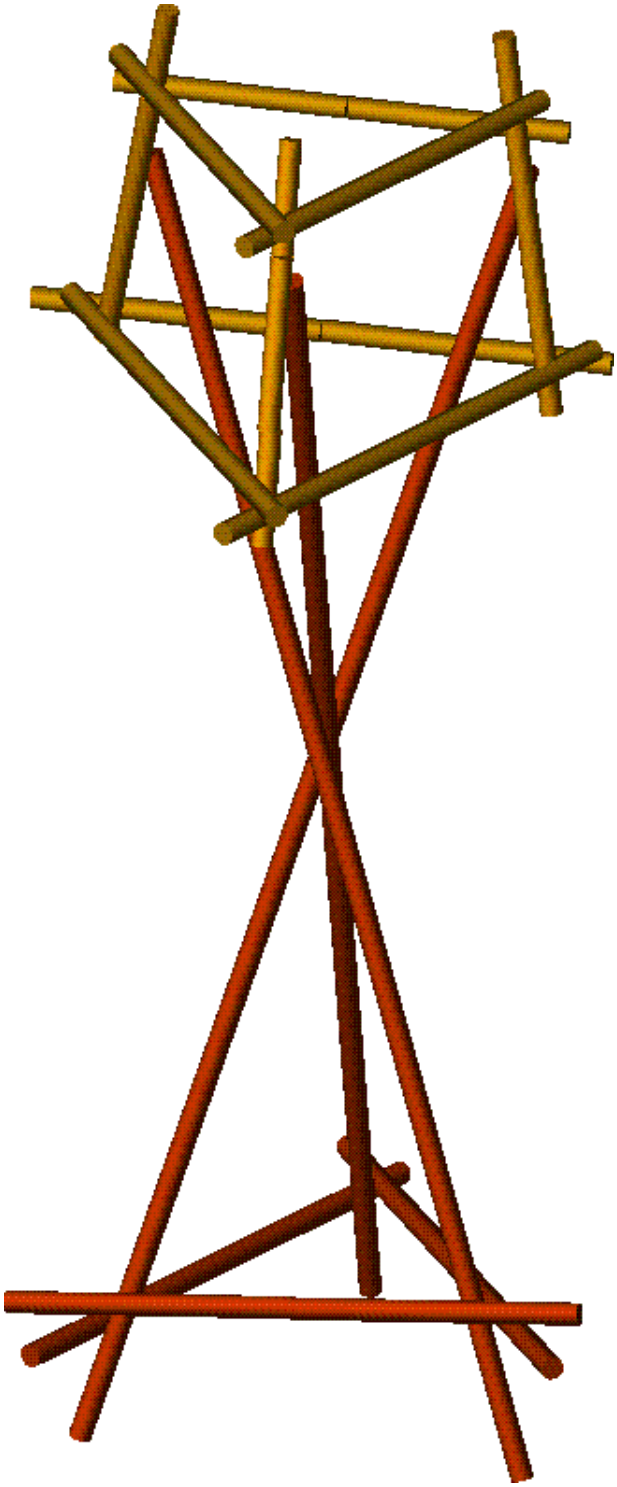
Brynbach Tower

The Brynbach Tower is made from three long, heavy spars -- at least 15 feet each. Lash them together just above the middle as shown, and put three bracing spars at the bottom. This forms the base of the tower.



The platform is made by lashing together nine spars as shown below. The bottom three spars are lashed to the main spars about 18 inches from the top. The three upright spars that form the handrail supports are tied to the base and then to the main spars to make them secure. The rails are then tied to the upright spars and a deck is lashed to the base. The completed tower is shown on the next page.





This is how the completed tower should look (without the deck). To climb up to the deck, you can make a rope and spar ladder.

top or standing end, tied to top of tower.

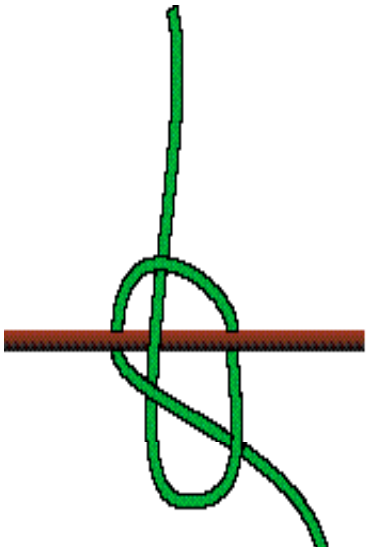
Begin with an overhand loop.

standing end.

running end

Holding the ropes where they cross, bring the bottom of the loop up toward the top.

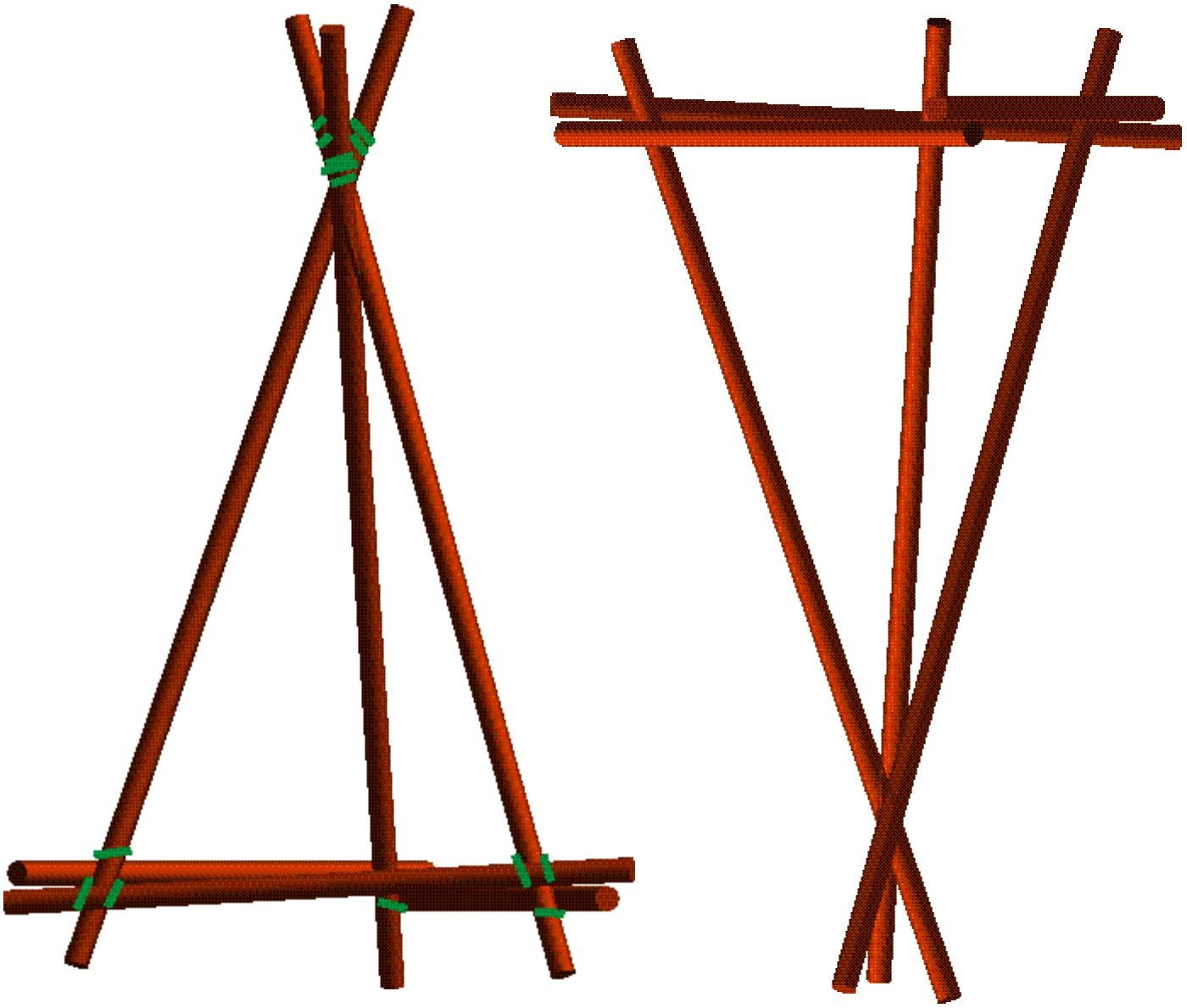
standing end



Insert a spar as shown, over one side of the loop, under the standing end and then over the other side of the loop. Make sure the spar is heavy enough to support your weight. You will notice that the rope forms a half hitch at the bottom of the spar. When you stand on the spar, it will push against this knot and keep it tight. (This knot is known as a Marlinspike Hitch.)

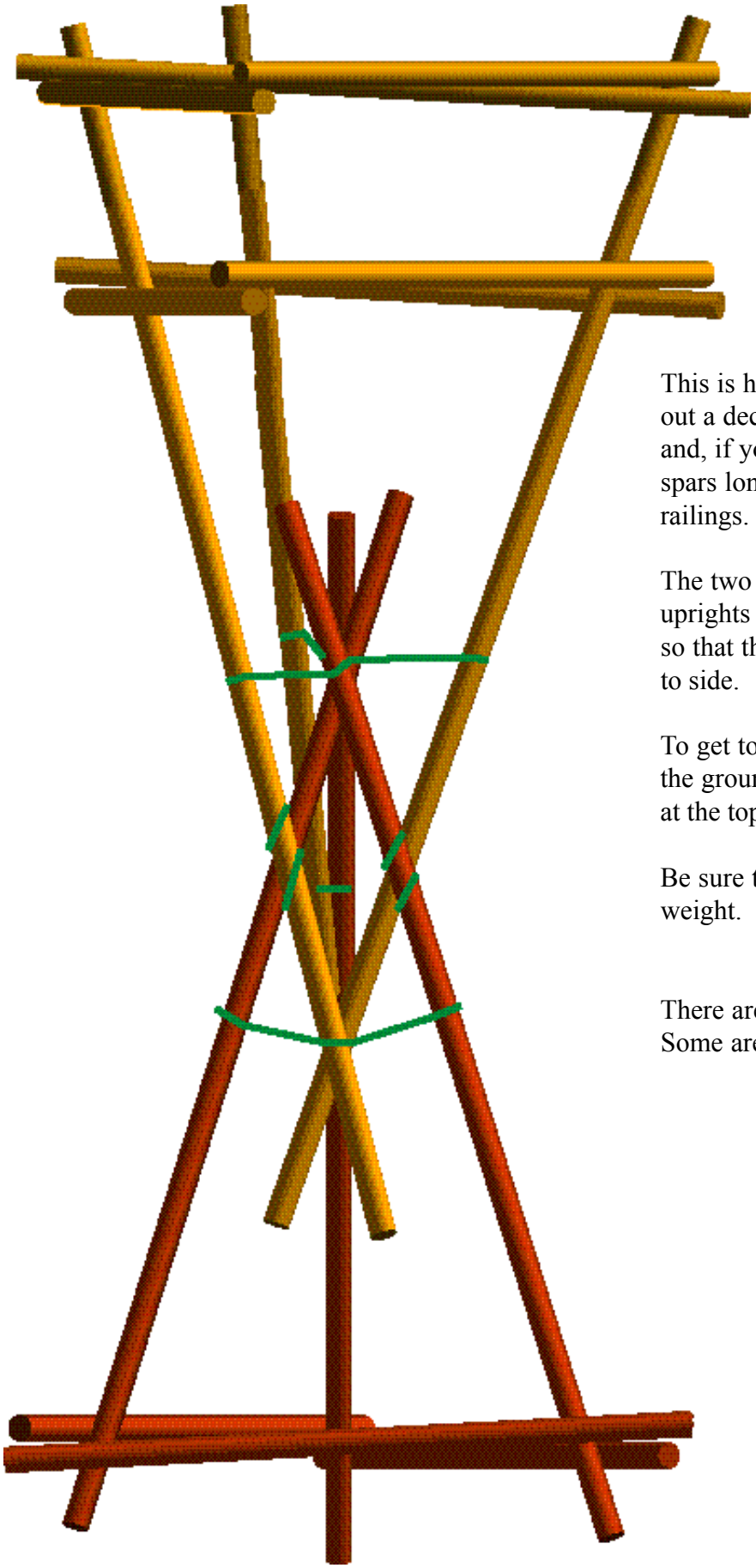
Do the same thing on the other side of the spar, then add enough spars to reach from the handrail to the ground. *Hint:* If you tie the bottom of the ladder to two stakes and pull it tight, it will be easier to climb.

Hourglass Tower



The Hourglass Tower is made by lashing two pyramids together. Begin by making the pyramid on the left. Then make the pyramid on the right, but do not lash the "top" together. Notice how the second pyramid has been turned around after being flipped over.

Lash the two pyramids together as shown on the next page. Lash the long spars of the upper pyramid to those of the lower pyramid first; then lash the "top" of the upper pyramid together.



This is how the finished tower should look without a deck. Lash planking to the top of the tower and, if you need a handrail, make the top upright spars longer and add three more cross-spars as railings.

The two pyramids are lashed together where the uprights cross. and extra ropes have been added so that the top pyramid will not sway from side to side.

To get to the top, make a rope ladder staked to the ground on the bottom and tied to a handrail at the top.

Be sure to use strong spars to support your weight.

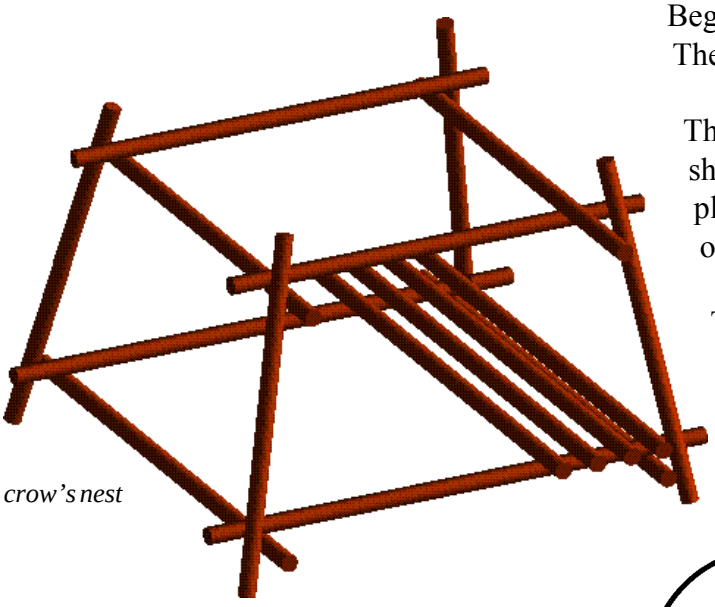
There are many other ways of building towers. Some are shown on the following pages.

Stilt Tower

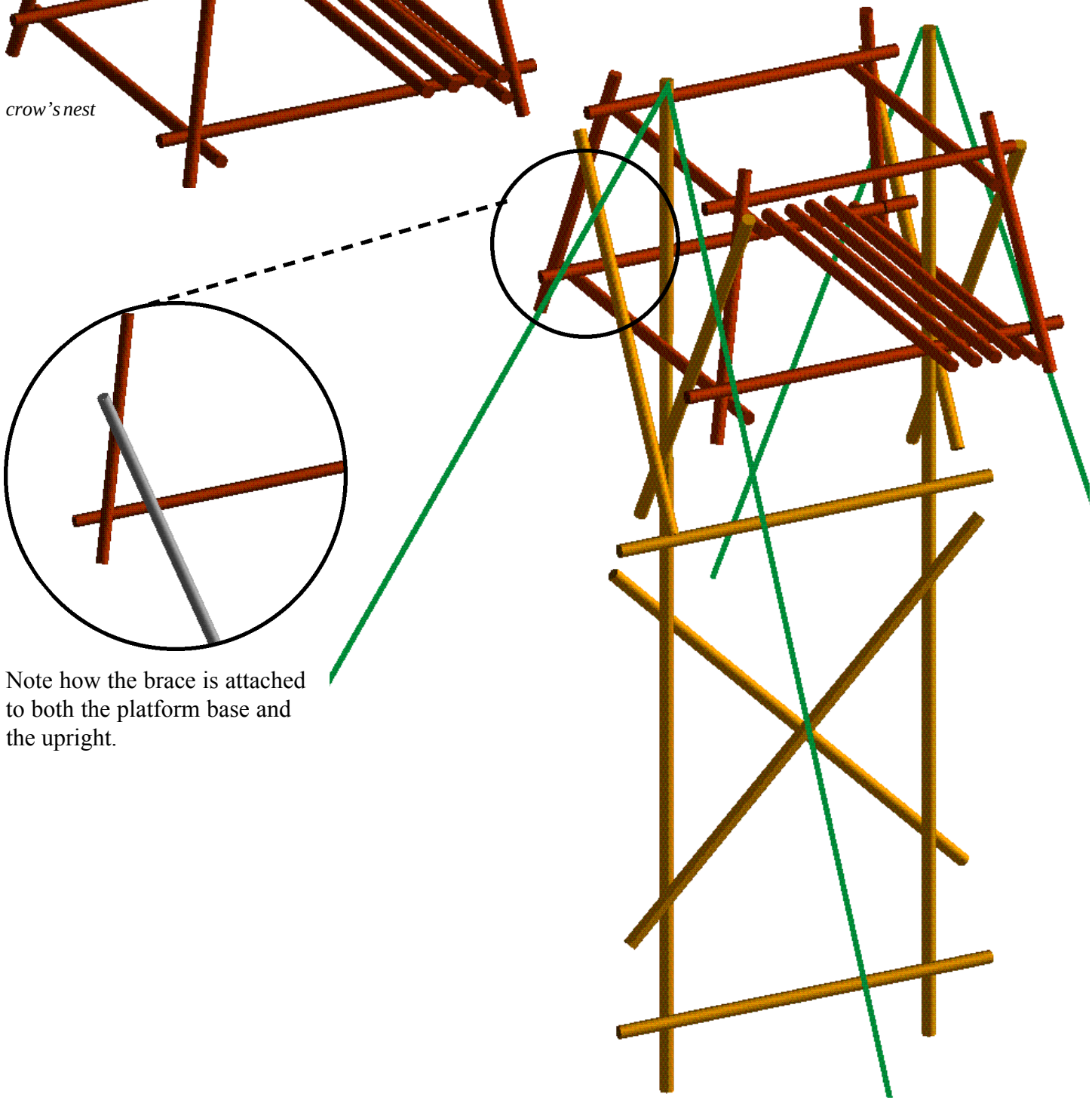
Begin the Stilt Tower by constructing your "crow's nest." The upright spars should slant inward.

This platform is lashed to two large upright posts, as shown below. The posts are braced to each other, and the platform is braced to the posts. Additional lines staked out to the side support the tower.

To reach the platform, attach a rope ladder.



crow's nest



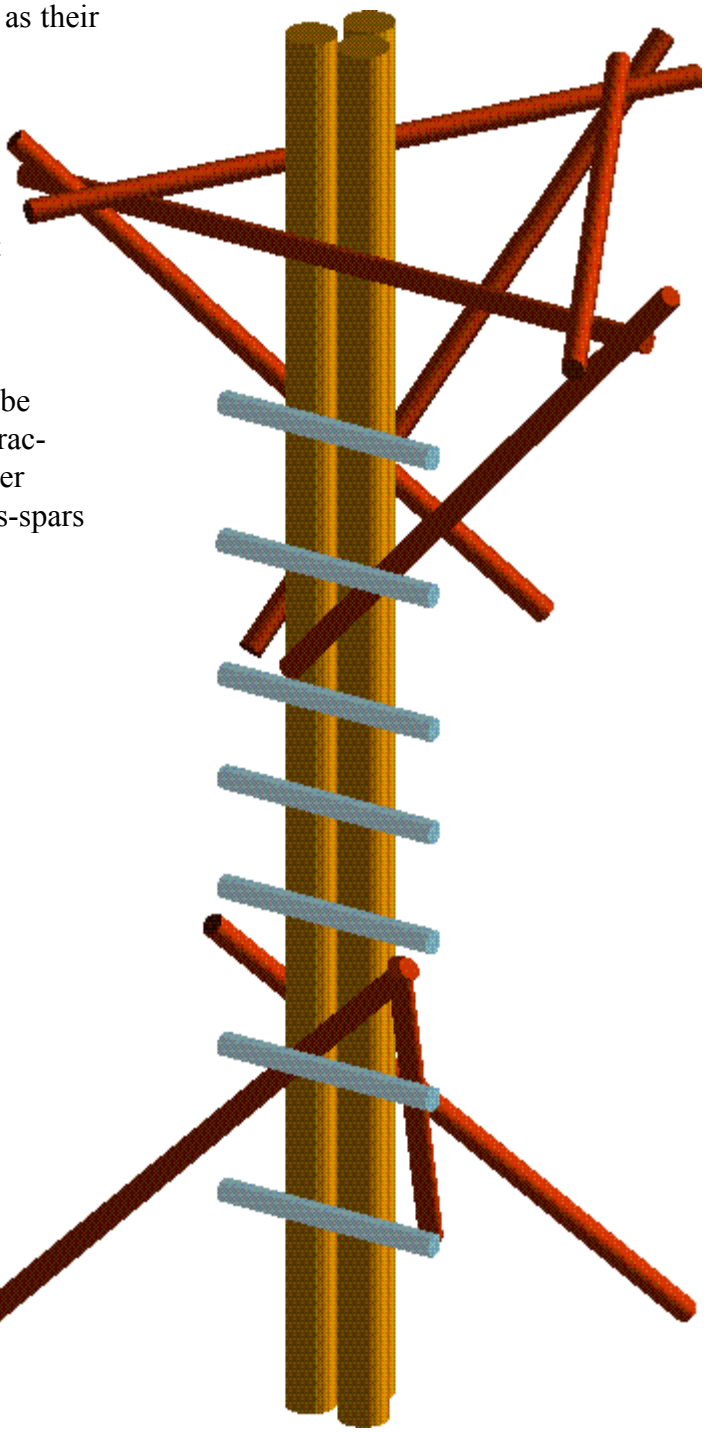
Note how the brace is attached to both the platform base and the upright.

Monopole Tower

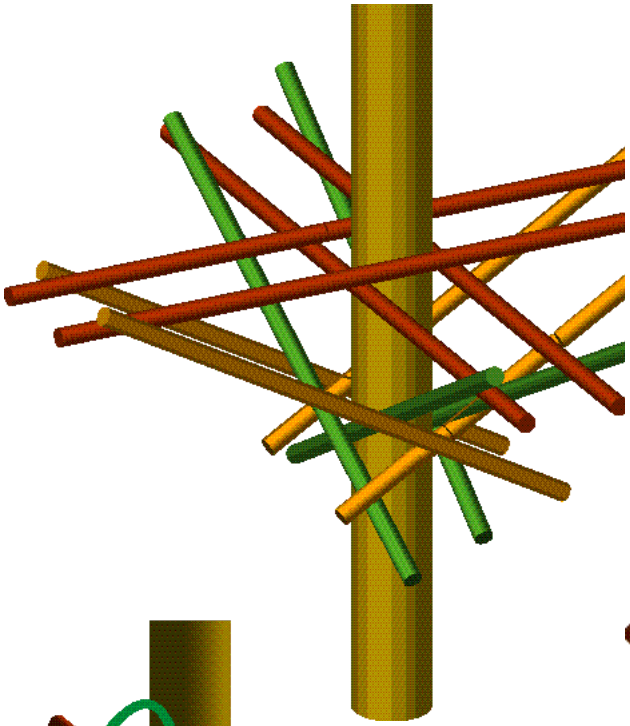
The next three towers use large trees or telephone poles as their base.

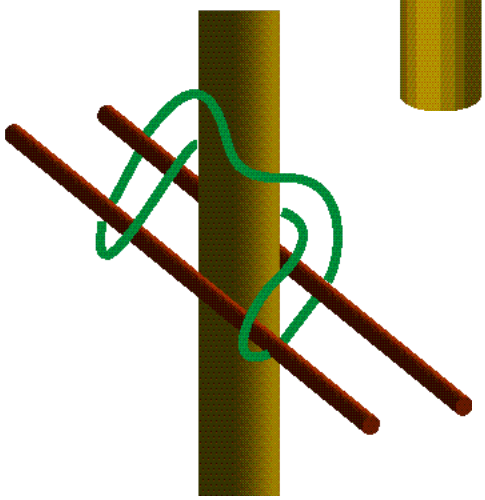
<u>Remember:</u> You must be very careful any time you use a tree for one of these projects. Spars and even ropes can damage or kill a tree. Always use some kind of padding under ropes and spars that come into contact with the tree!

The Monopole Tower is shown with three large upright spars lashed together as the base. They are too large to be driven into the ground, so they are supported by three bracing spars placed like a tripod around the bottom. Another "tripod" forms the top (deck not shown), and more cross-spars make the ladder.



Tree Stand





The structure on the left really isn't a tower at all, but a Tree Stand. It's made with four long spars braced by eight spars. The deck is not shown. Lash the long spars to the tree as shown on the left.

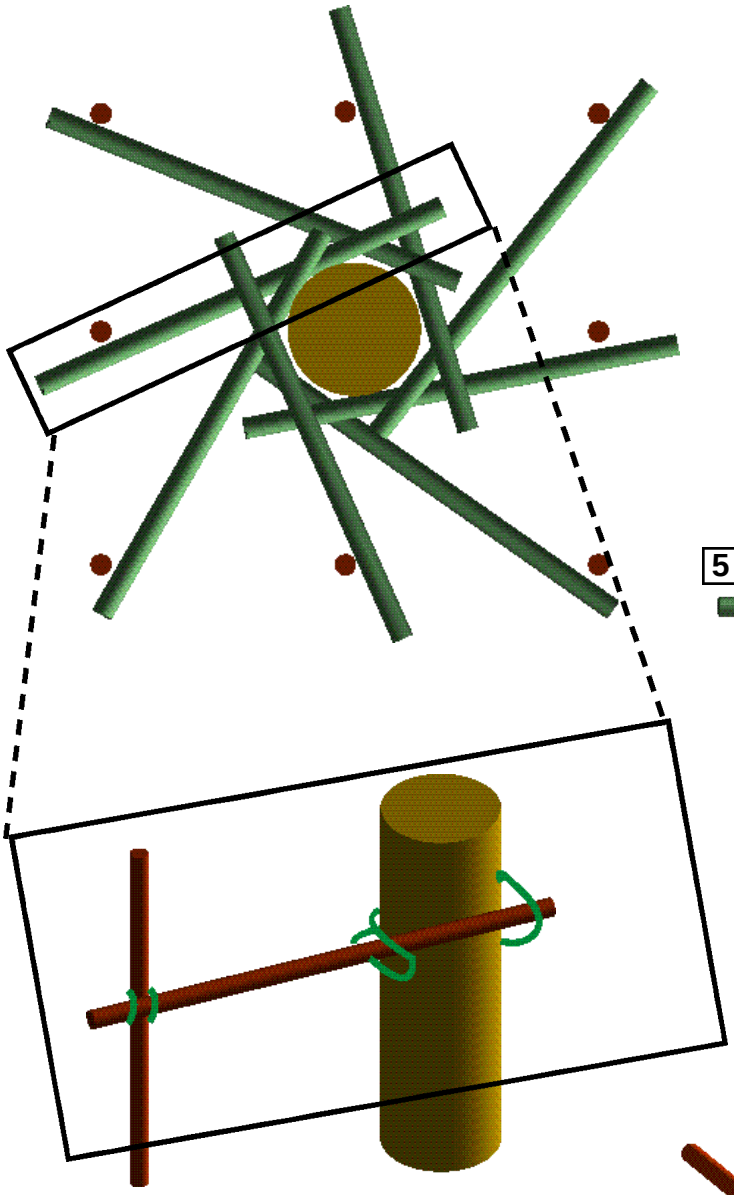
Look at the close-up of the Spiral Stairs on the next page to see how the braces for the Monopole Tower and the "rungs" for the Tree Stand are lashed to the tree.

You can reach the Tree Stand with a rope ladder.

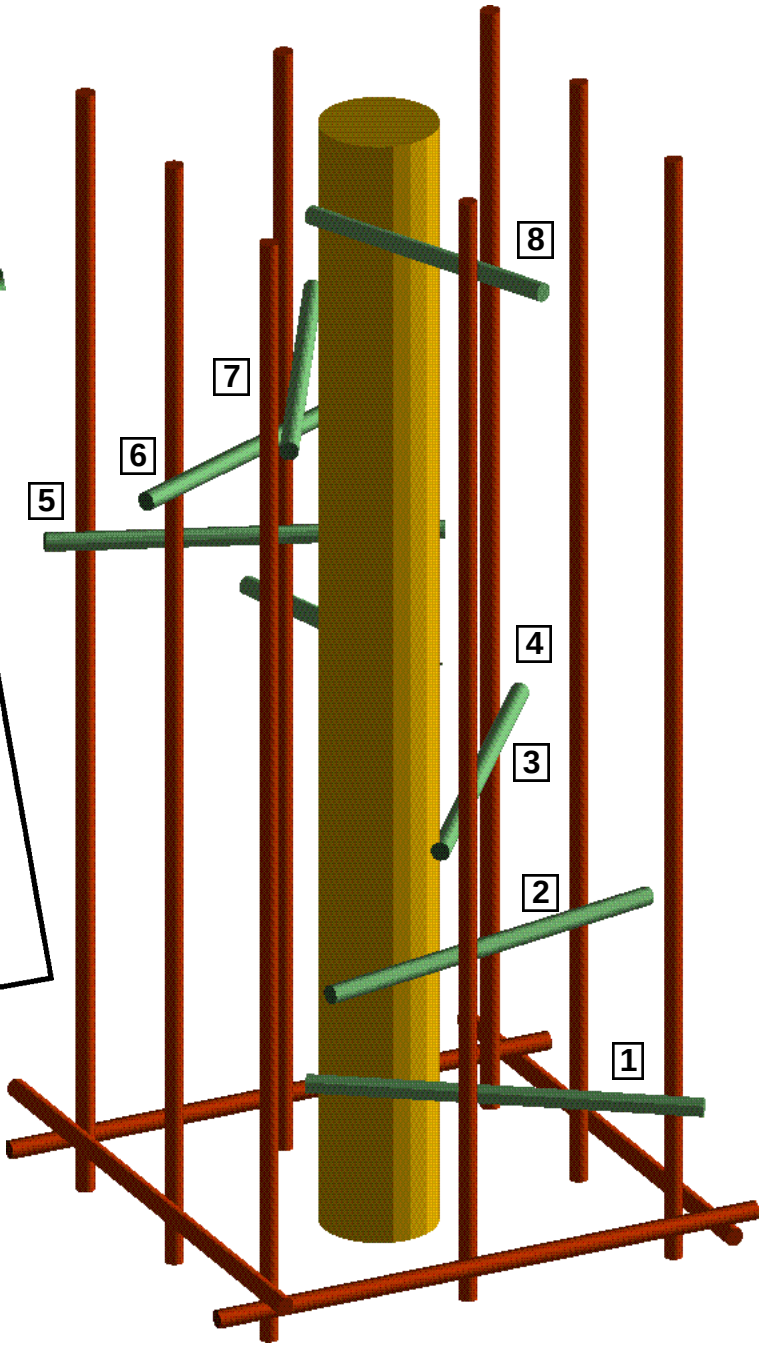
Spiral Stairs

Courtesy of Michael T. Dodson Nd "The Eagle Patrol, NE-I-93."

The Spiral Stairs is not actually a tower and it requires a good-sized tall, straight tree with no low branches. To make it you need eight long, heavy spars placed in a circle around the trunk and braced with cross-spars at the bottom. Between the trunk and each upright spar is lashed a rung (green).



This is a top view of how the uprights and steps are placed around the trunk of the tree.

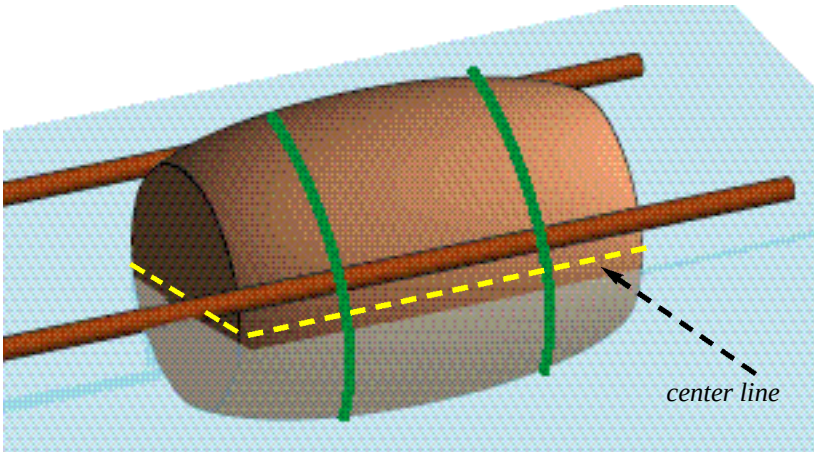


The figure on the right shows the completed Spiral Stair. Only the bottom set of braces is shown. The higher the stairs, the more braces are needed. The lowest step is numbered "1," then "2," "3" and so on, up the trunk. You can hold onto the uprights for balance or lash handrails between the uprights.

CHAPTER X
THINGS THAT FLOAT

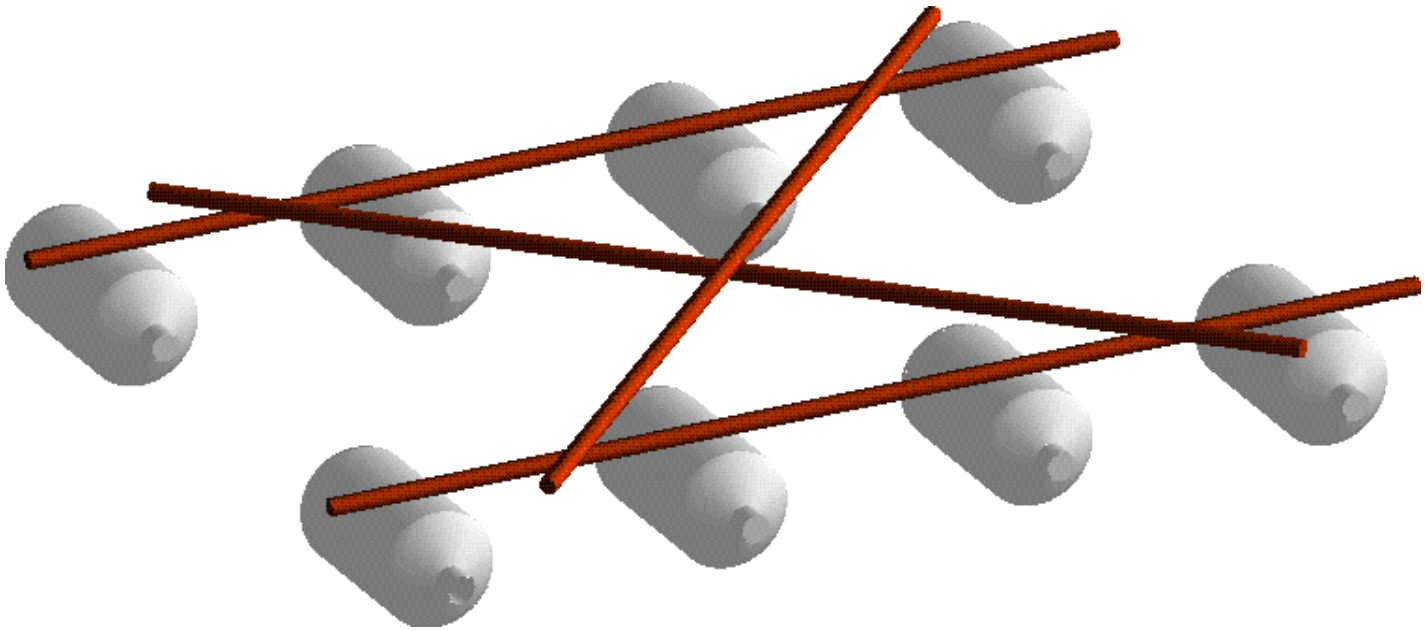
Rafts

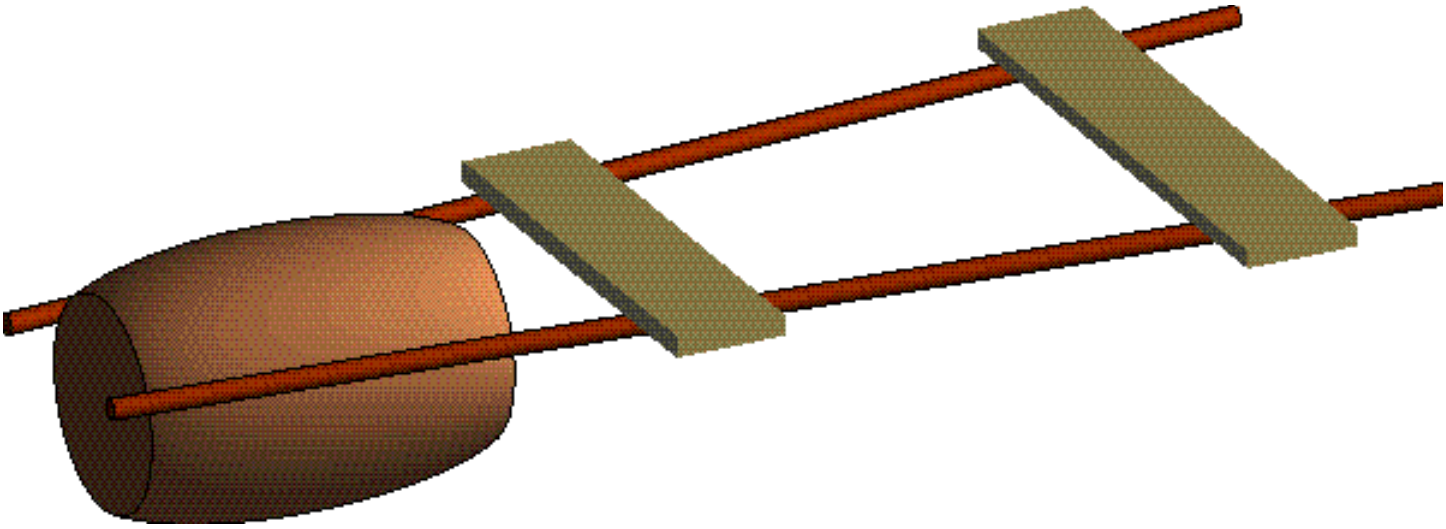
Rafts need special materials. Some use wooden planks. All use something to make them float. I have tried barrels, one-gallon plastic milk containers or anything else that will float and support the raft and you.



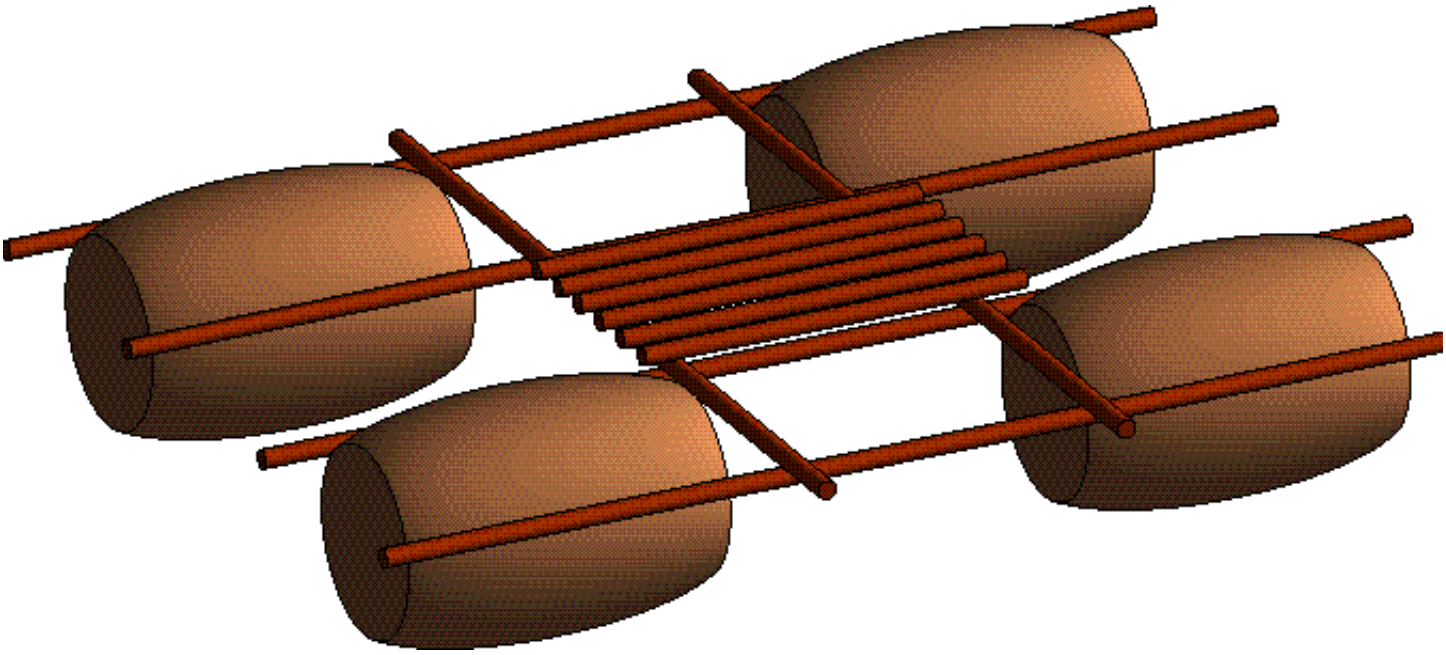
Any time you use a barrel or other "cylinder," you must attach the spars as shown. They must be lashed above the center line. Otherwise, when you try to sit on the raft, the barrel will pop up through the spars, and you will sink!

This is a very simple raft. You can make it with anything that floats. Just use as many as it takes to support your weight and the weight of the spars. In this case, the spars are lashed across the cylinders, not alongside. That way you don't have to worry about their slipping off.



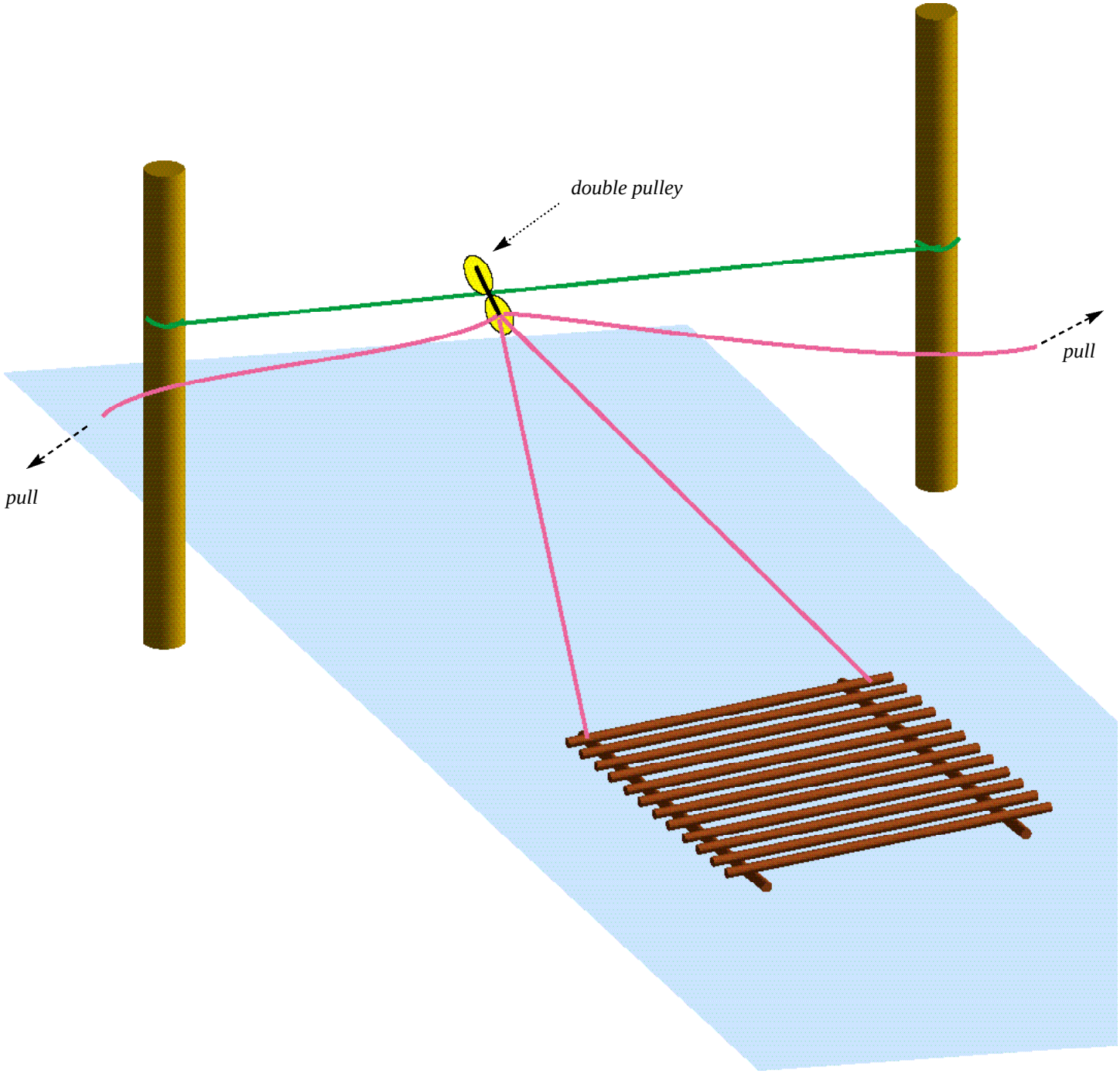


Here's a one-person raft made with one barrel, two spars and two wooden planks. You sit on the plank next to the barrel with your feet dangling in the water. Note that the two long spars spread out as they get farther from the barrel. That will keep the raft from tilting to either side.



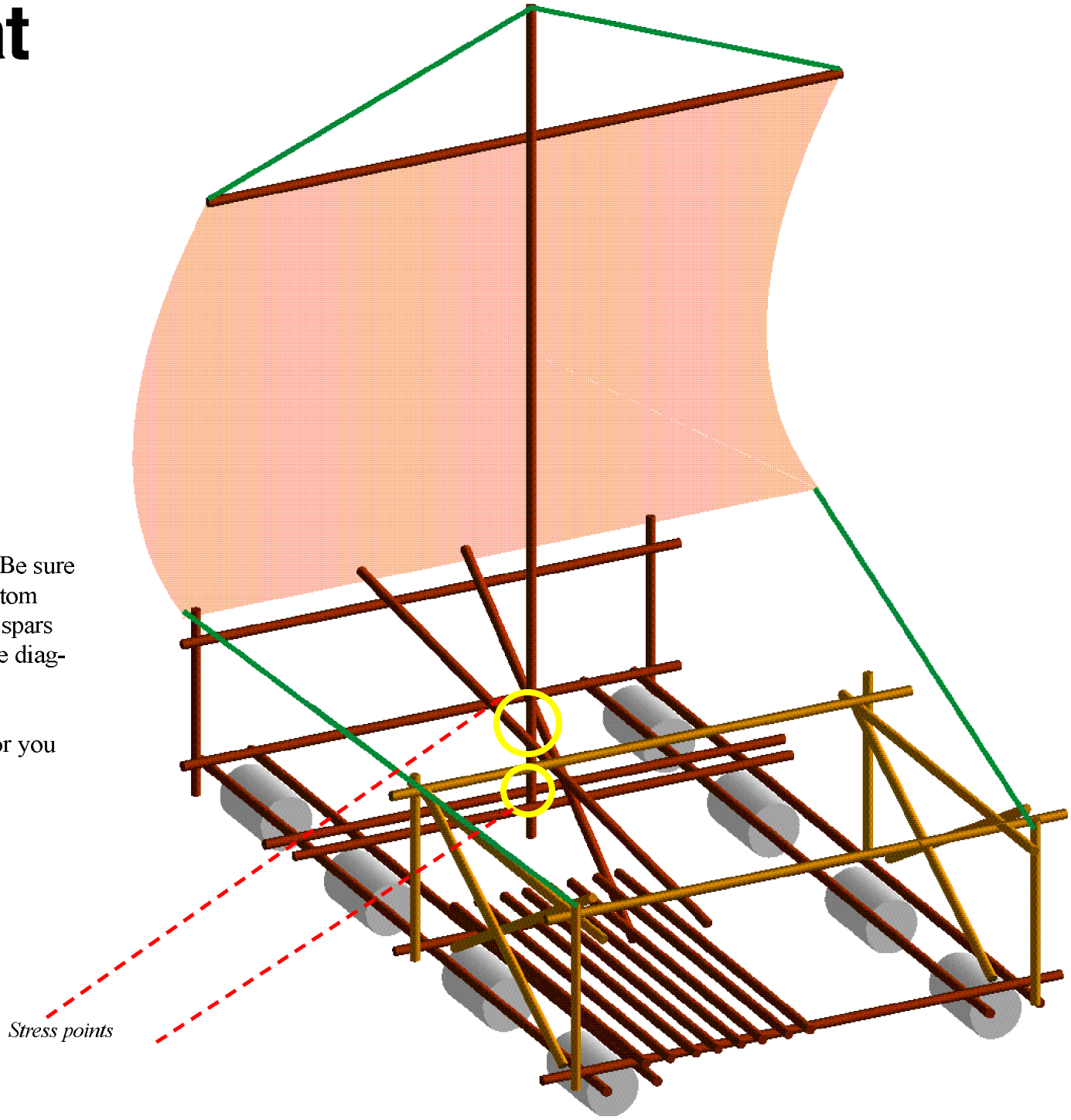
This raft uses the same basic structure, but has more barrels and spars. It will carry more people.

Ferry



Another way of using a raft is as a ferry. Stretch a heavy line (green) across a river between two trees. (Be sure to pad the trees.) Put that line through a pulley and attach lines from the sides of the pulley to the raft. Two more lines running from the pulley (or from the raft) to either shore will allow you to pull the raft back and forth across the river. This only can be used on slow-moving water. Swift rivers will put too much strain on the heavy rope.

Sailboat



And here's the biggest -- a sailboat! Be sure that the mast is well lashed at the bottom where it goes between the two lower spars and also higher up, where it meets the diagonal spars.

The platform can be low, as shown, or you can lash it on top of the "handrails."

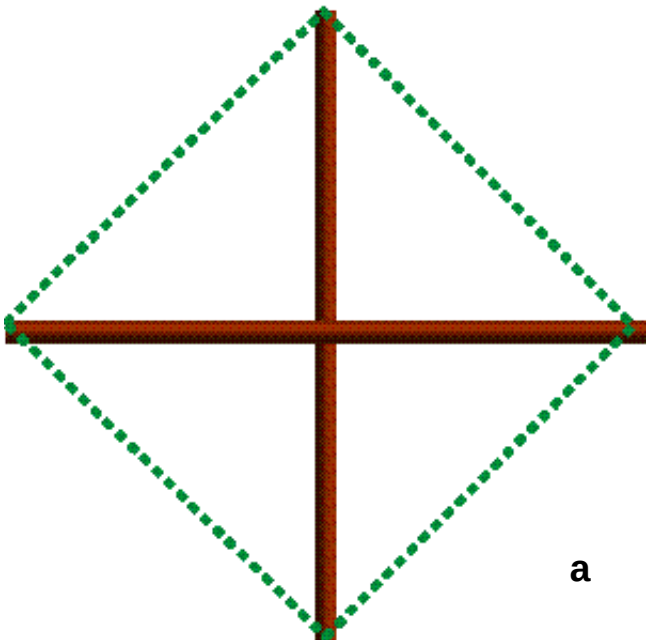
CHAPTER XI
ROPE & SPAR MAGIC

Tensegrity Models

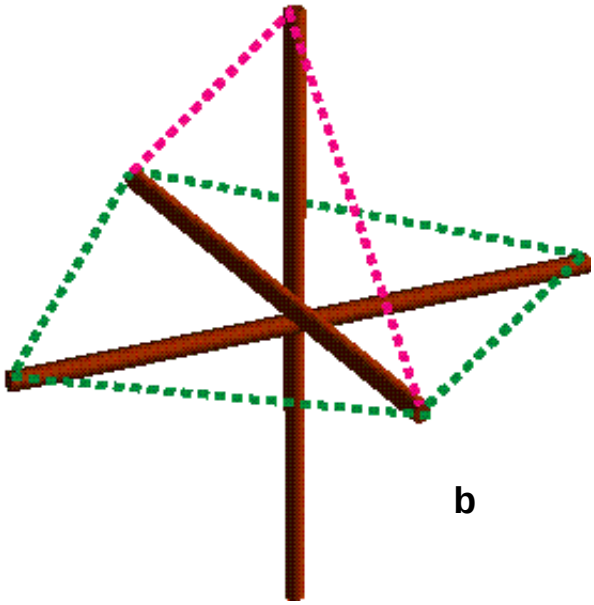
Now for some magic! Everything we have built so far has used the spars to make the form and provide strength. Our ropes were used mainly to tie the spars together. In this chapter we are going to build Tensegrity Models, where the rope and the spars share in forming the shape and providing the strength. The magic is that, in most of the models, none of the spars touch.

Let's see how it's done. The simplest one has three spars and eight ropes. There are two ways of putting it together.

First, cross two of the spars and tie the ends together to form a square (a).

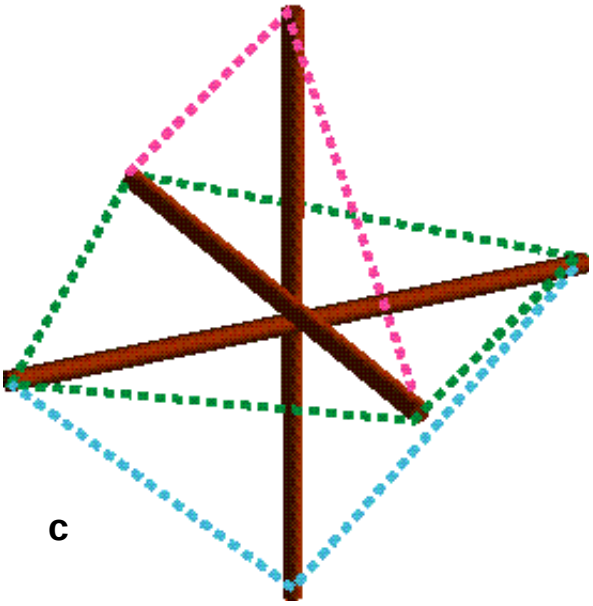


a



b

Now place the third spar as shown and tie one end of this spar to one of the cross-pieces (b).

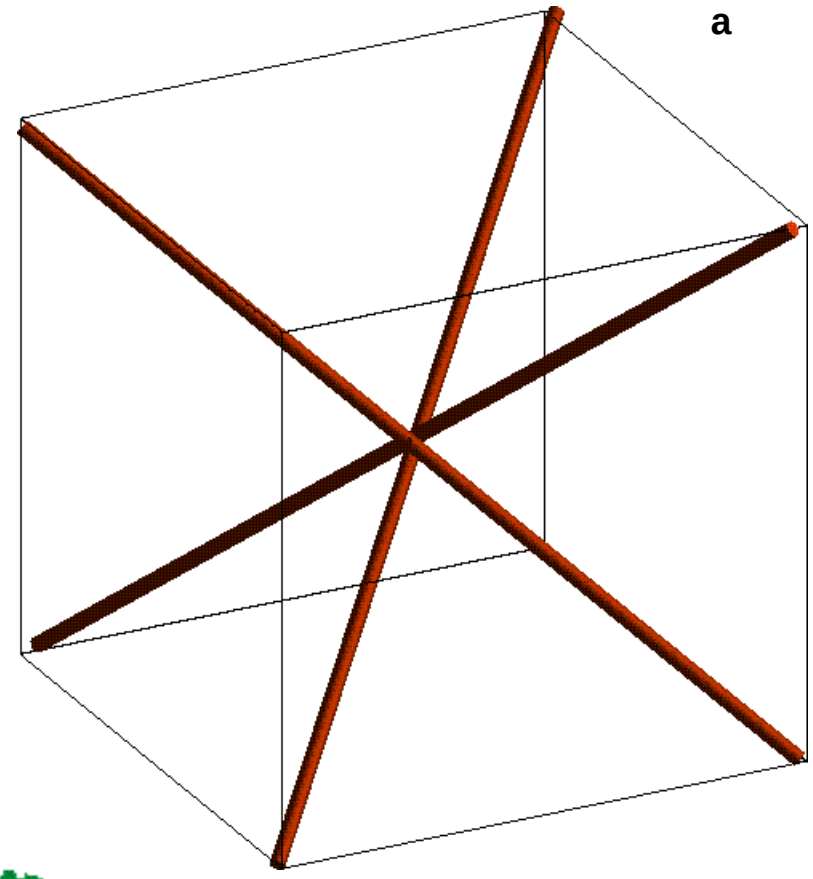


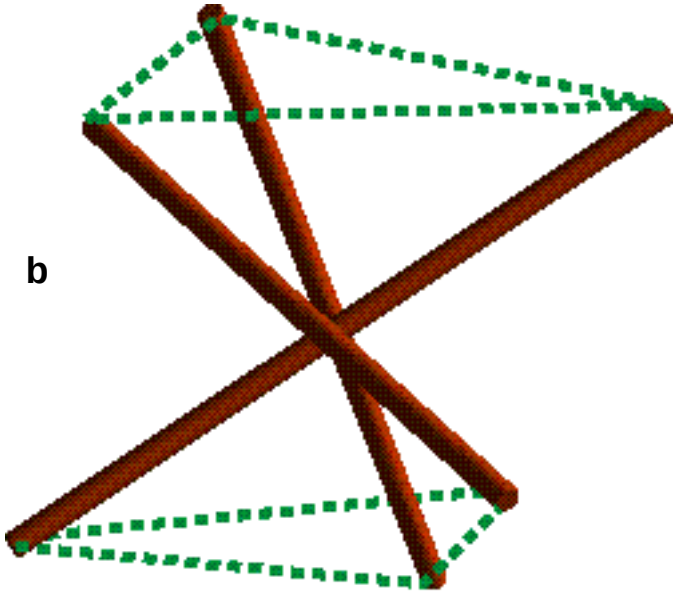
c

Then tie the other end to the other cross-piece (c).

You can see that the three spars touch one another, but they do not support each other. (If the ropes are of different lengths, the spars will not touch at all.) Why doesn't the structure fall apart? It's magic!

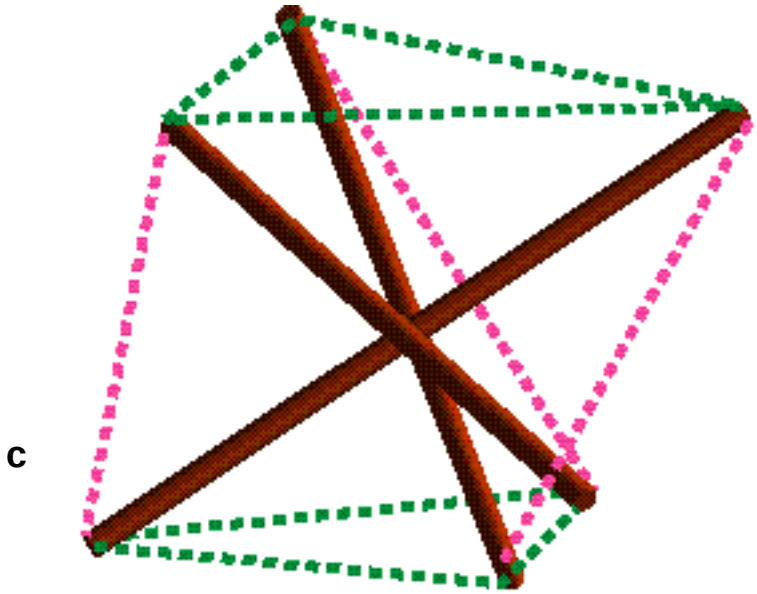
There is another way to make the same form. Place the three spars as if they were joining six corners of an imaginary cube (a).



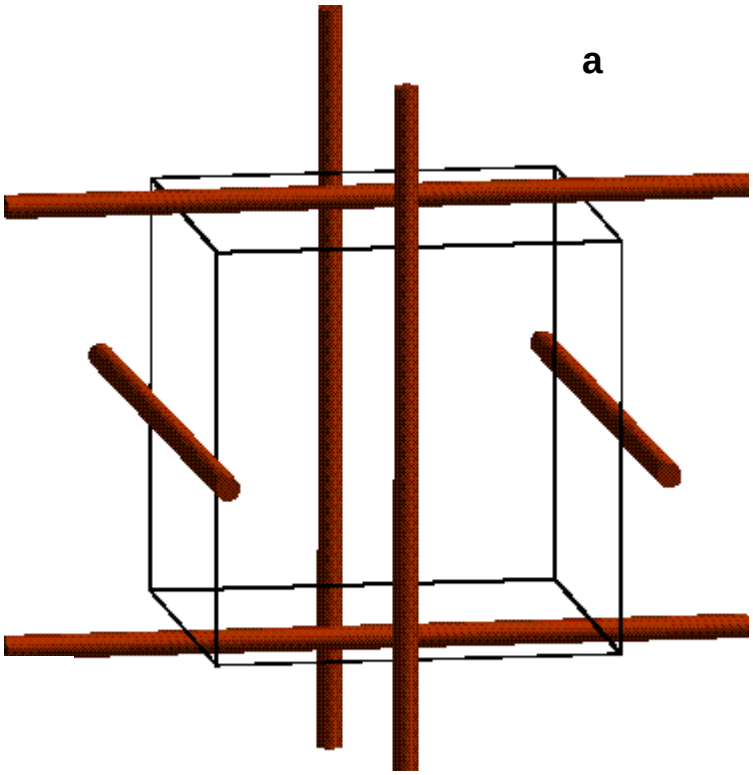


Now tie the three top ends and the three bottom ends together (b).

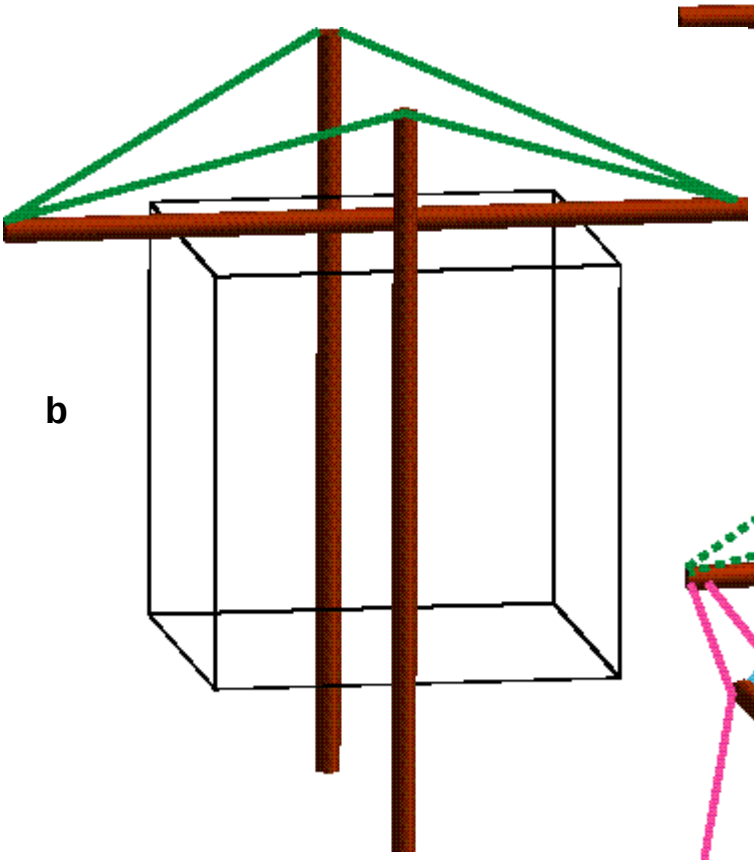
Then tie each top end to one of the bottom ends (c). Again, the spars touch (unless the ropes are of different lengths) but do not support one another.

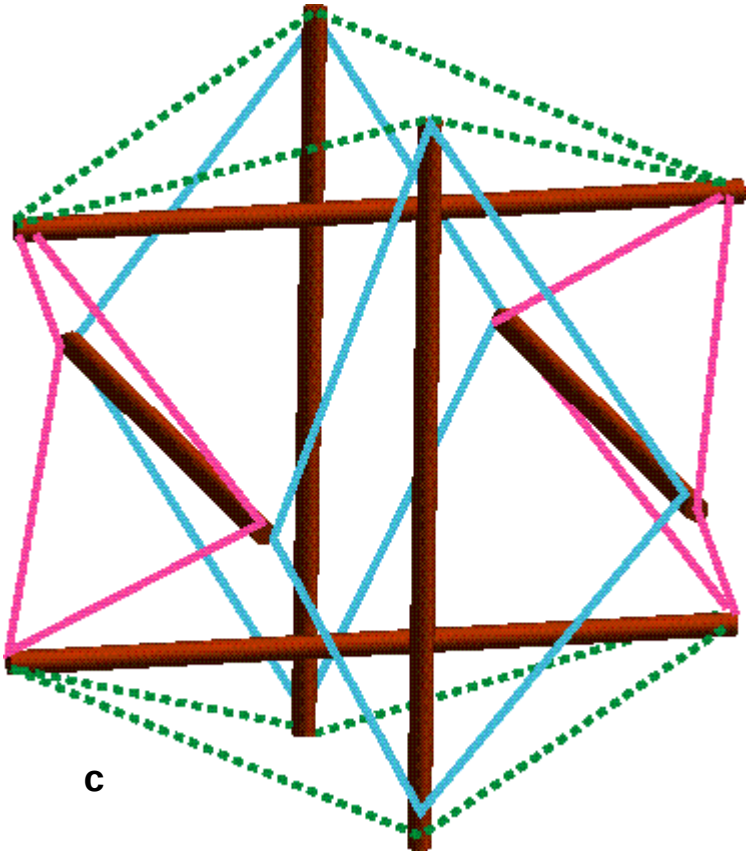


For the next model we will use another imaginary cube again. This time we will start by placing six spars, one on each side, as shown in “a.”



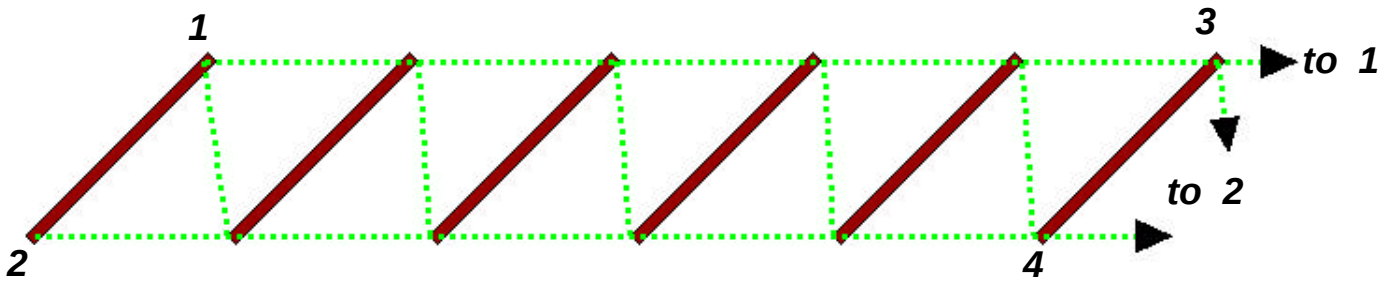
Each spar is held in place by four ropes running to the two ends above the spar (b).





Do the same for each of the spars in the model “c.” This looks difficult, but if you will look carefully, you will see that it is made up of “b” repeated for each of the six spars. When you are finished, every end should have four ropes attached to it. This time none of the spars will touch at all, even though all the ropes are the same length!

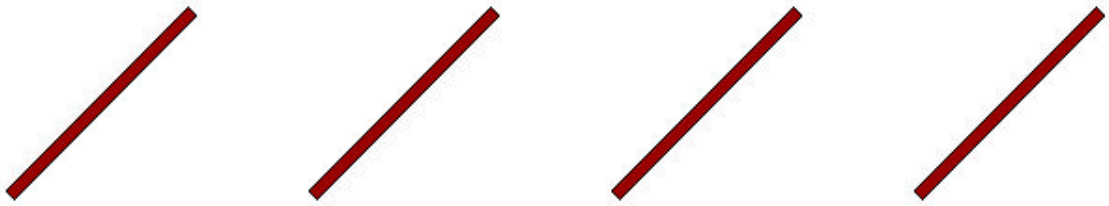
There is another way to build this model. Lay the spars out as shown in “a.”



a

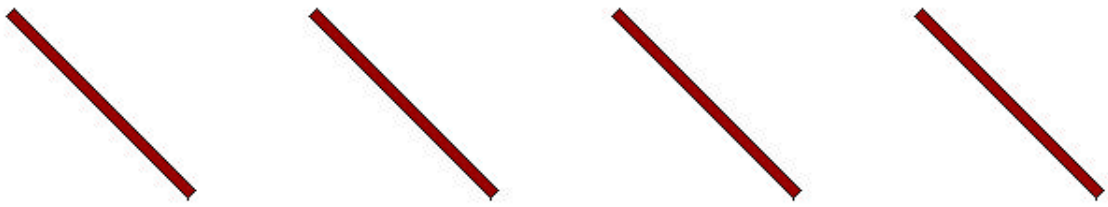
Tie them all together as shown. Put a large piece of paper or cloth over the center and fold the ends together so that they meet in the center. Then tie 3 to 1 and 2 and 4 to 2. Make sure that all the ropes are the same length.

This model can be made larger by changing the length, number and arrangement of the rows. Begin the next model with four spars, as shown in “b.”



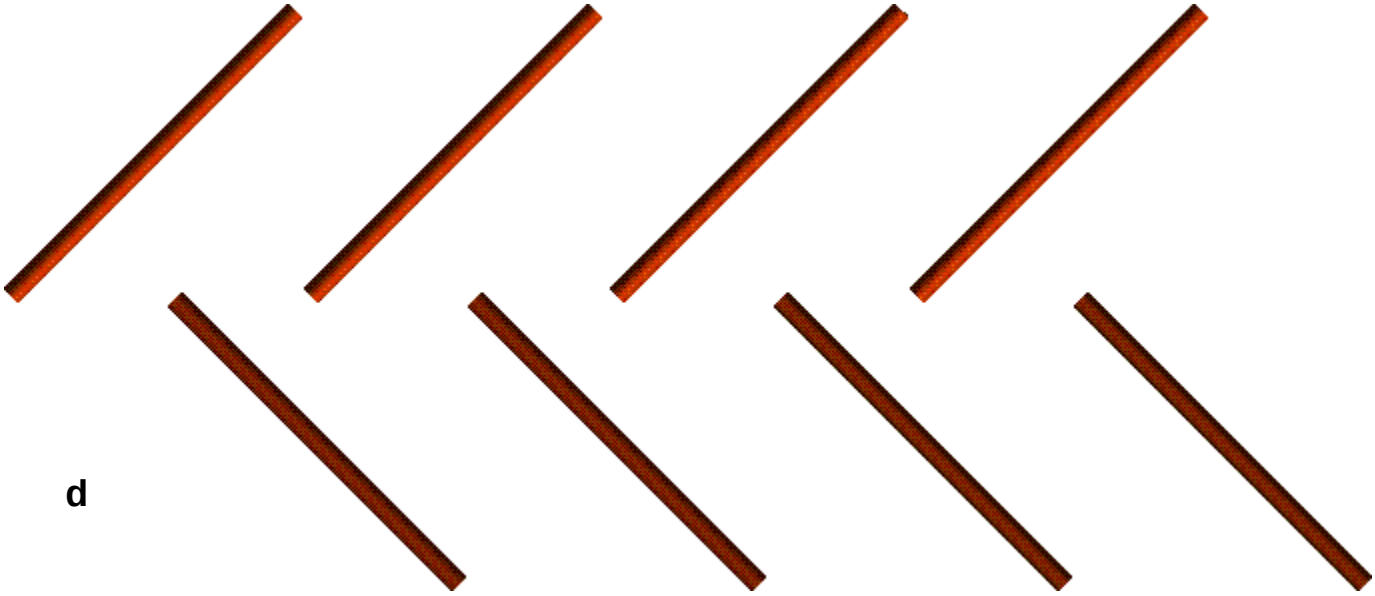
b

Then, add four more, laid out as in “c.”



c

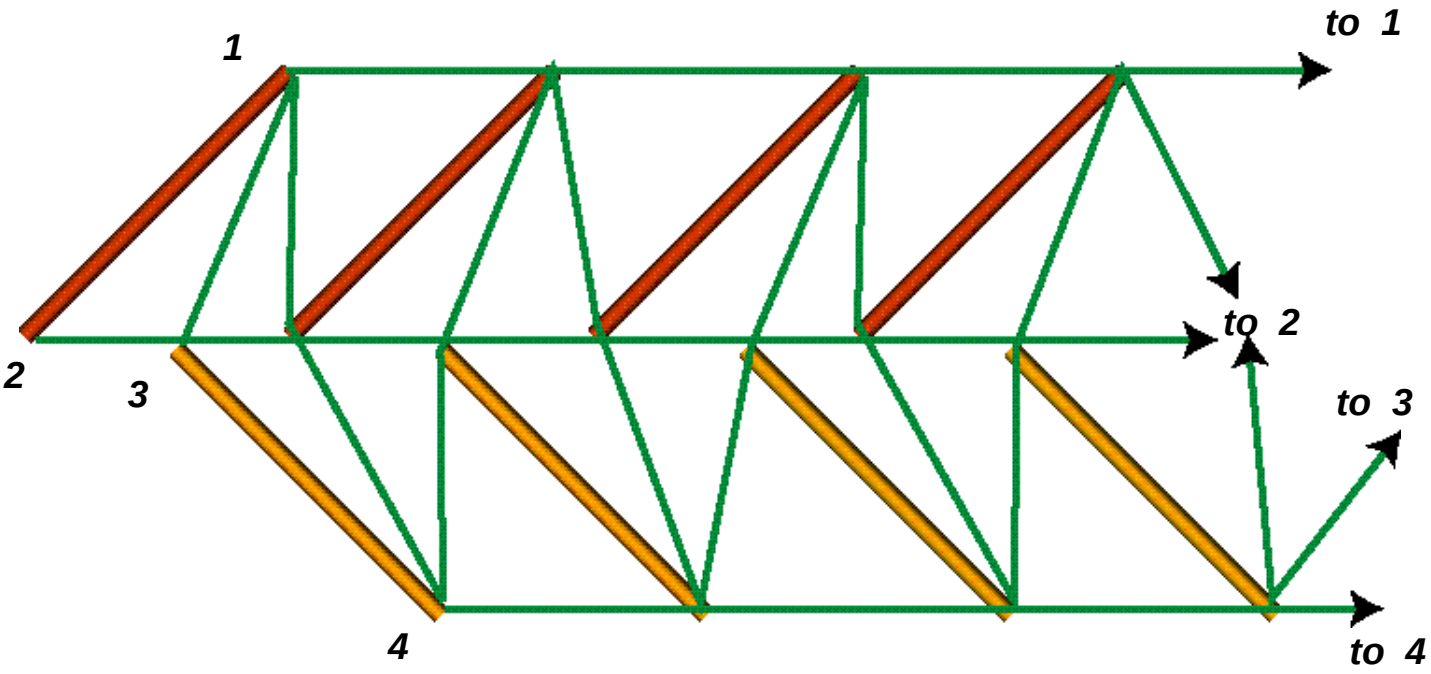
Put the two rows together, as shown in “d.”



d

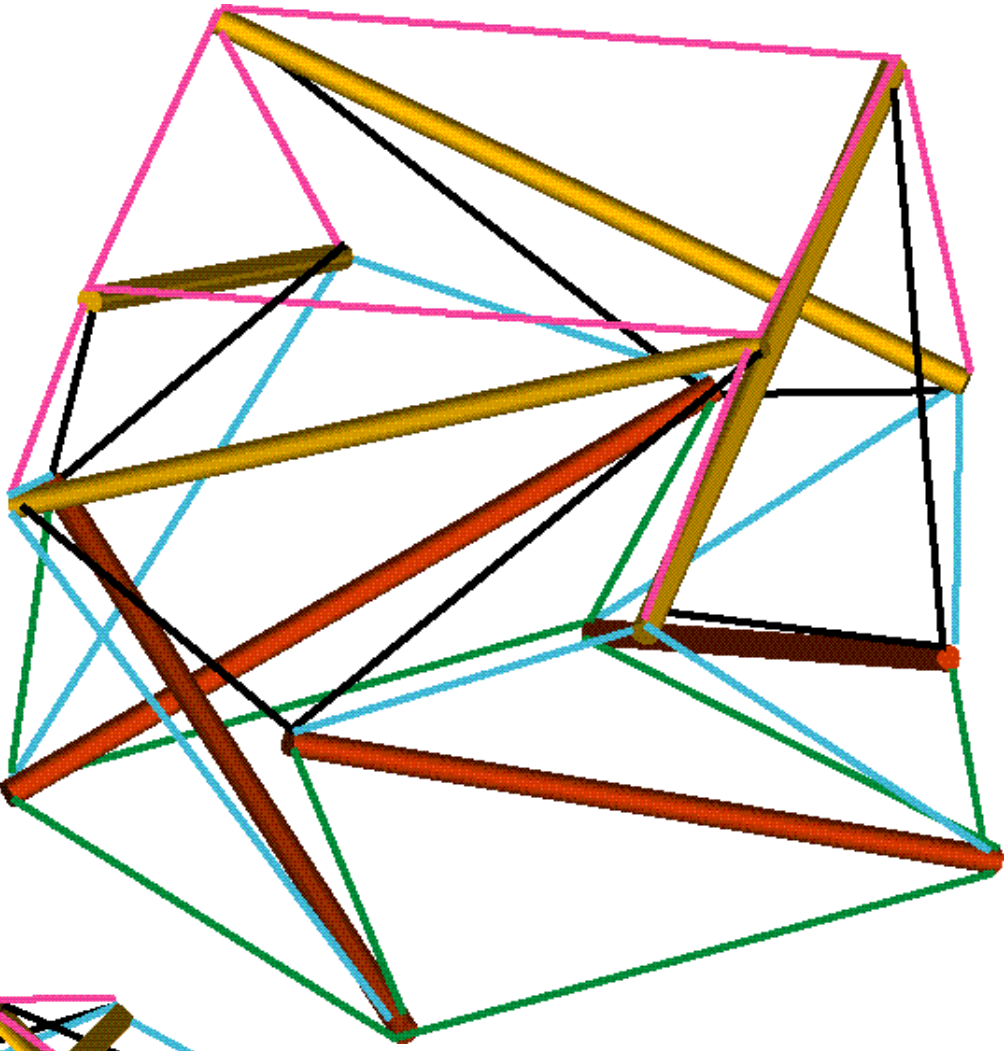
Tie them together, then tie the ends together, as shown in “e.”

e

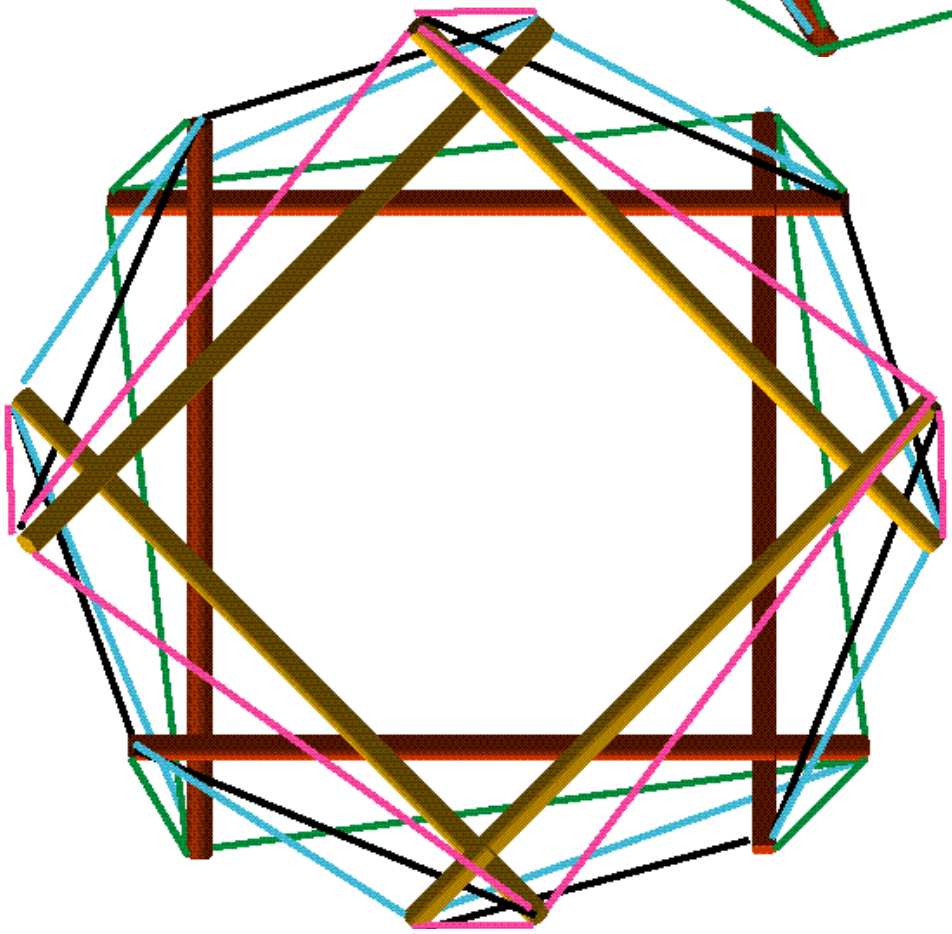


Each rope should be about the same length, but when you first tie the spars together, the ropes at the top and bottom will have to be longer so the spars can lie flat on the ground. After you finish tying the two ends together, you can shorten those ropes so that all the lines are about the same length.

This is what the finished model will look like.



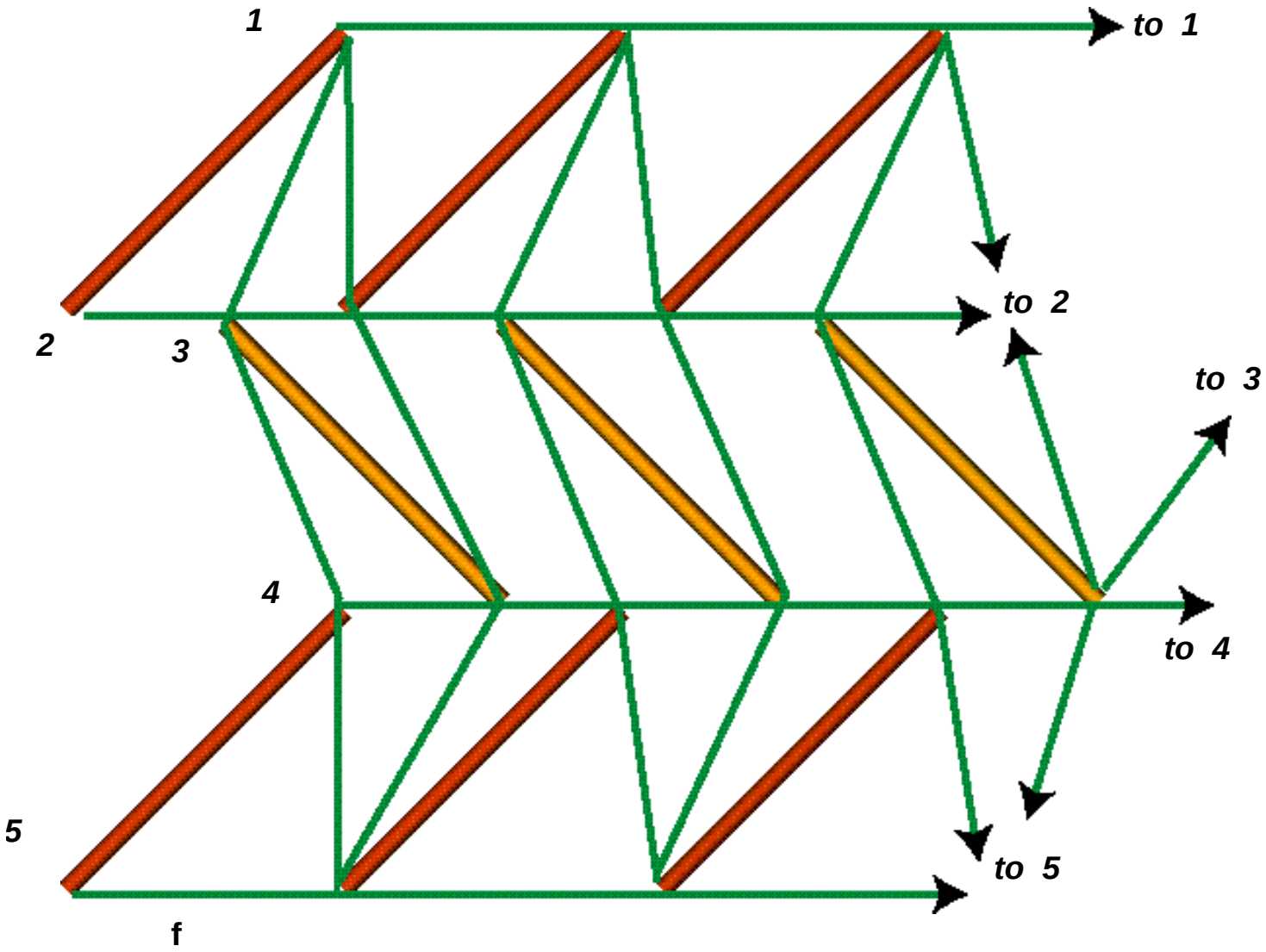
side view



top view

You can lengthen each row, using a total of 10 or 12 spars, in the same pattern, to make more difficult models.

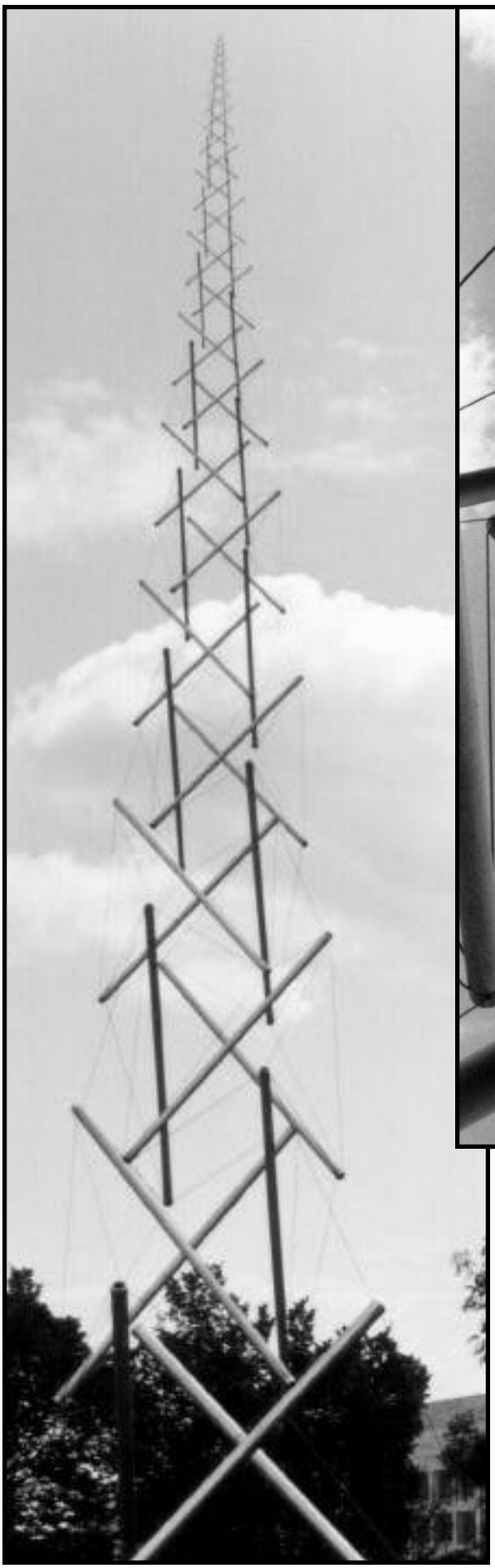
You also can increase the number of rows, as shown in “f.”



This model has nine spars. By adding to each row, you can have 12, 15 or even 18 spars. Constructing a model with 18 spars (three rows of six spars each) would make you a master model-builder! You can even make a model with four rows of five spars each; a total of 20 spars.

Increasing the number of rows gives you taller models.

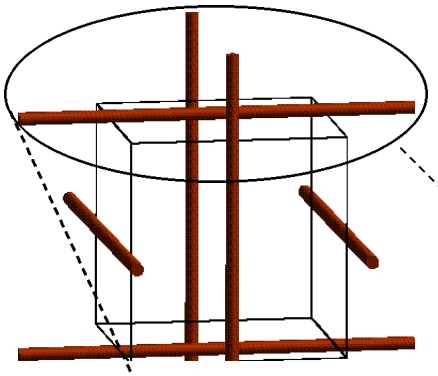
On the next page are two photographs of a tower that stands outside the Smithsonian Institution in Washington, D.C. It has over 20 layers, with three spars in each layer. (The spars in each layer are slightly shorter than the ones in the layer beneath.)



viewed up from bottom

viewed from side

Kenneth Snelson
Needle Tower, 1968
Aluminum & Stainless Steel
60 X 20 X 20 feet
Collection: Hirshhorn Museum & Sculpture Garden, Washington, D.C.



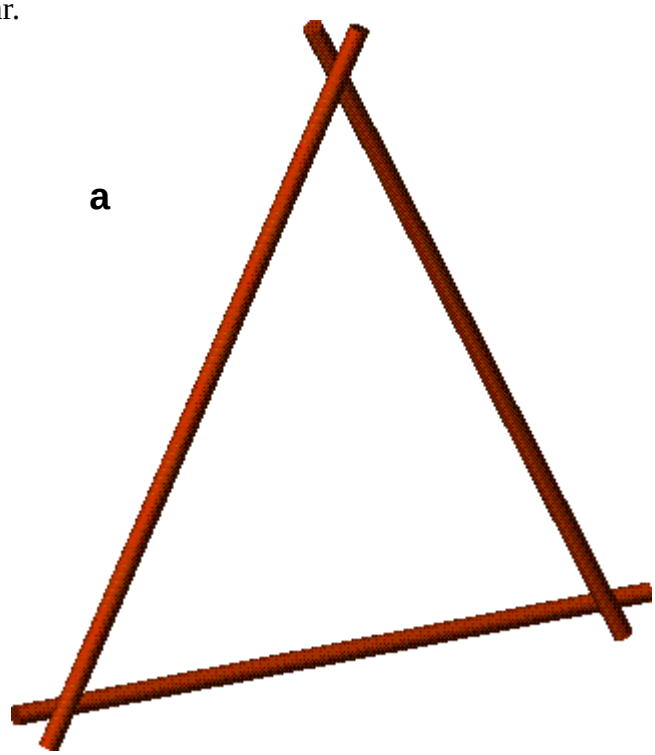
Now, go back to the 6-spar figure: You can combine eight of these models (or more) as shown below to make a very large structure. Where two spars meet end-to-end, use one longer spar instead (or join the shorter spars together using sheer or round lashings). Tie your lines at the middle and on the two ends of those spars.

Not all of the lines are shown, but you should be able to figure out where they go by looking at the original 6-spar figure.

Use the middle of the spar as if it were the end of two spars.

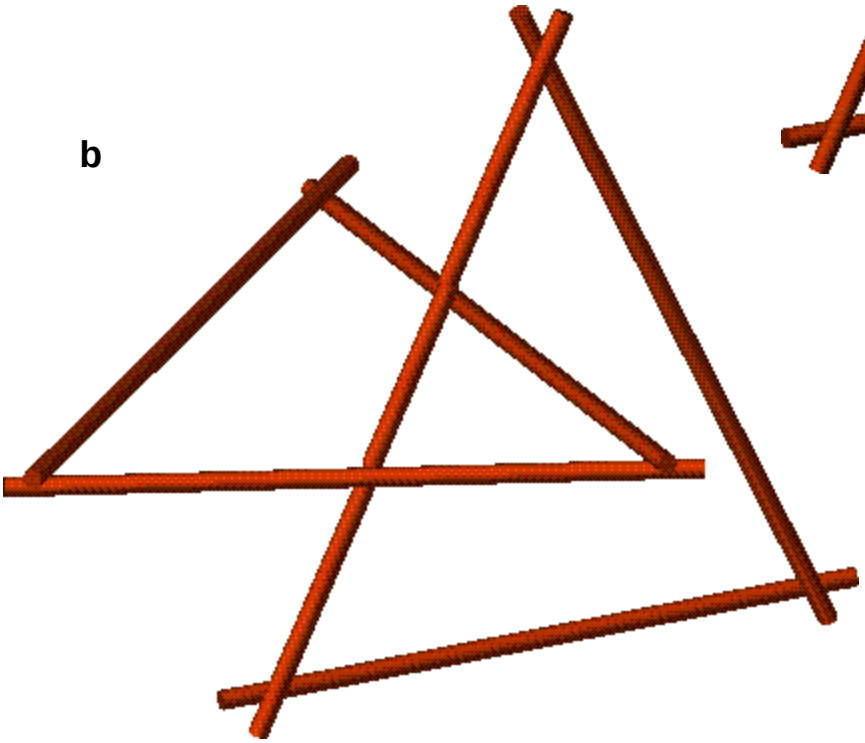
In each of the previous models, no spar touched another spar. By lashing together spars into simple forms, and then tying the forms together, you can make a whole different kind of model.

a



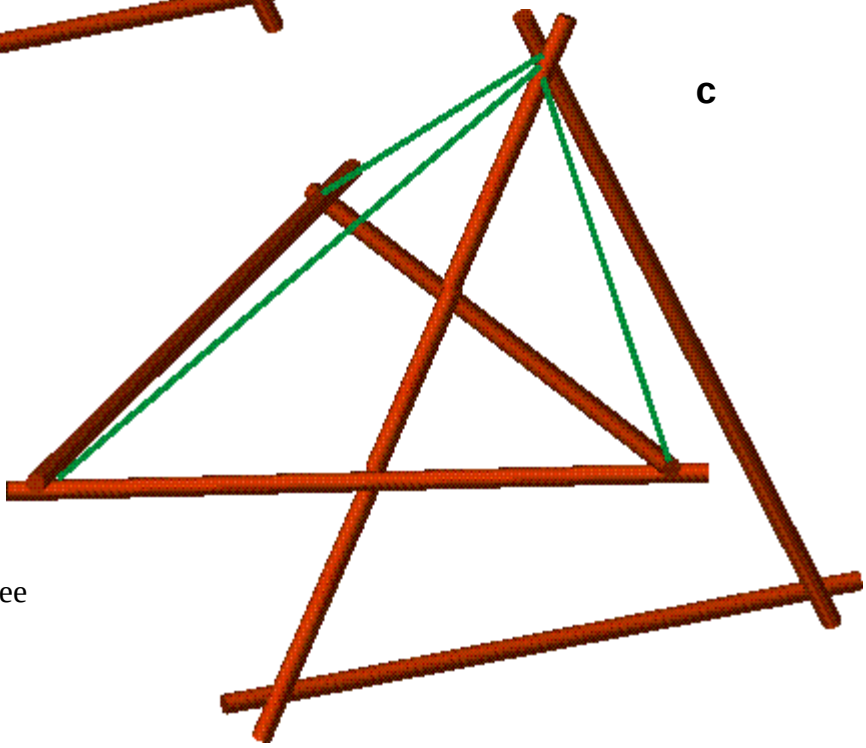
Lash together three spars in a triangle (a).

b



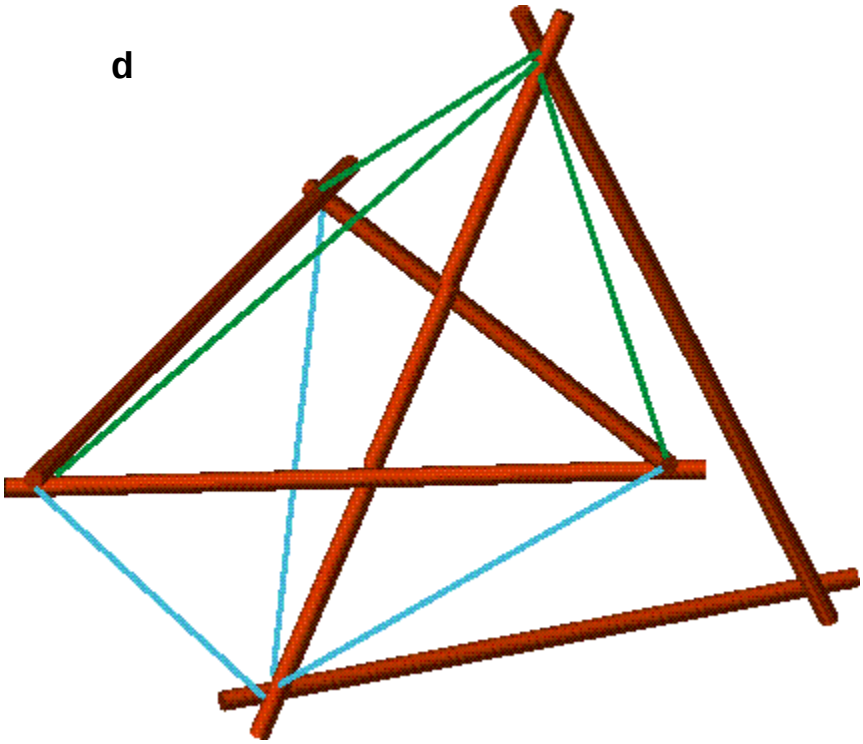
Now, make another one that fits around the first as shown in “b.”

c



From the top of the first triangle, attach three ropes to the tips of the second triangle (c).

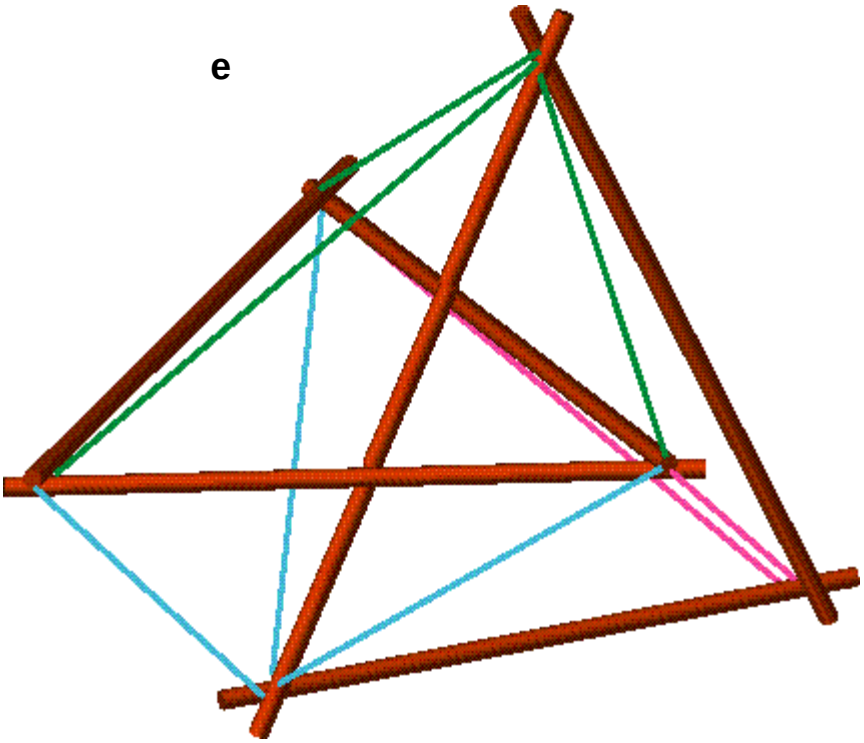
d



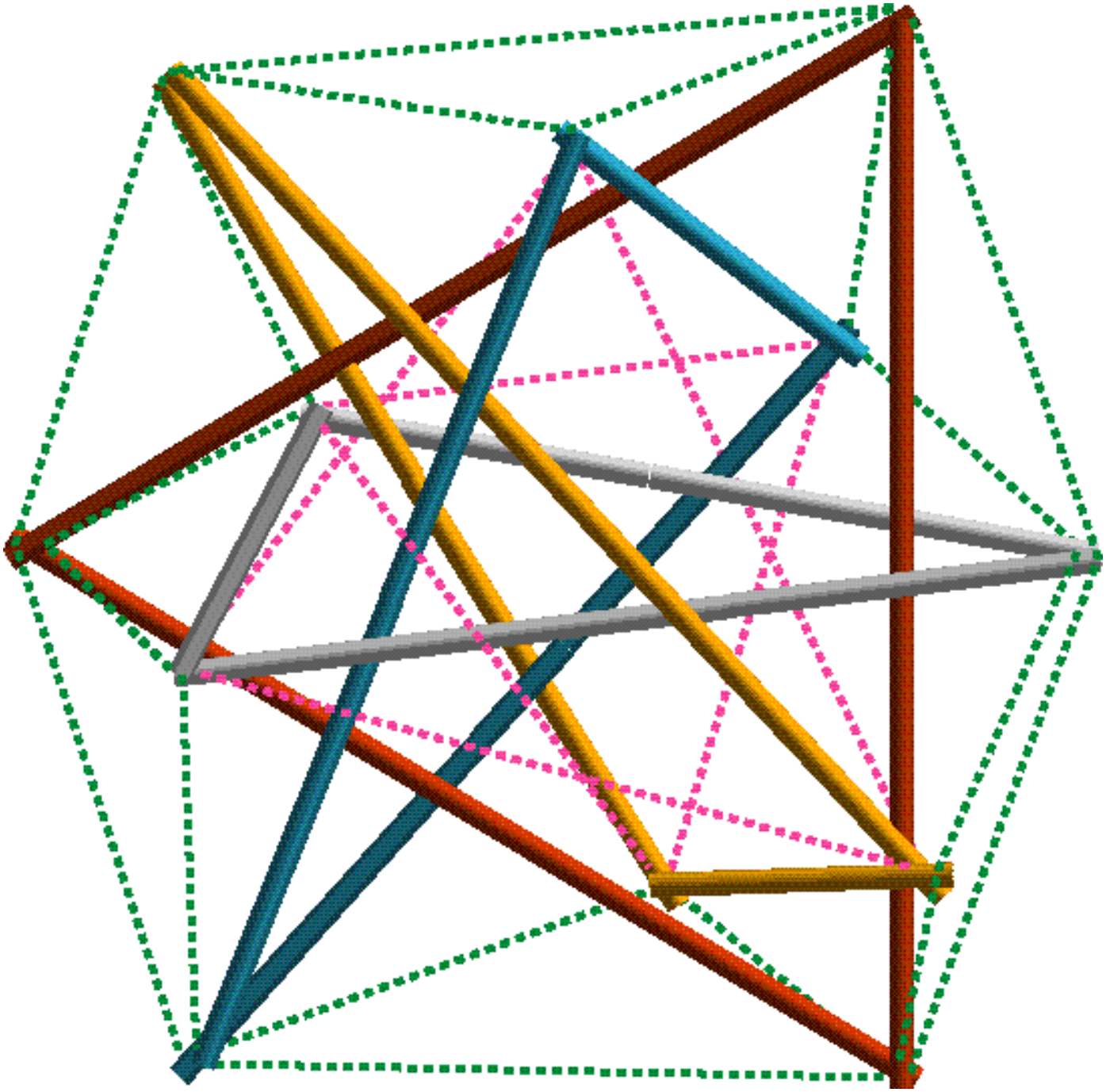
Do the same thing from the bottom (d).

You will see that one corner has no ropes. Run two ropes from that corner to the middle triangle as shown in “e.”

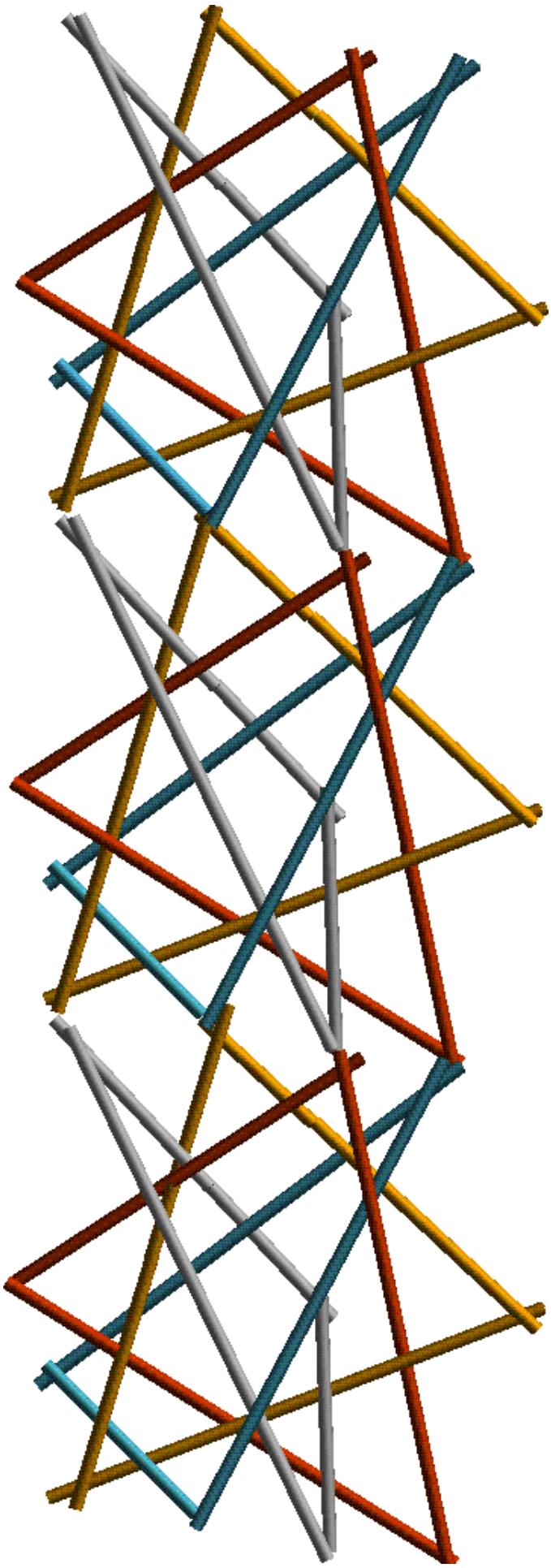
e



The model will stand up without the two triangles touching!



Here’s another model made with four triangles. Notice that each corner has four ropes; two are attached to opposite ends of the same spar. Each one of the other two are attached to different triangles.

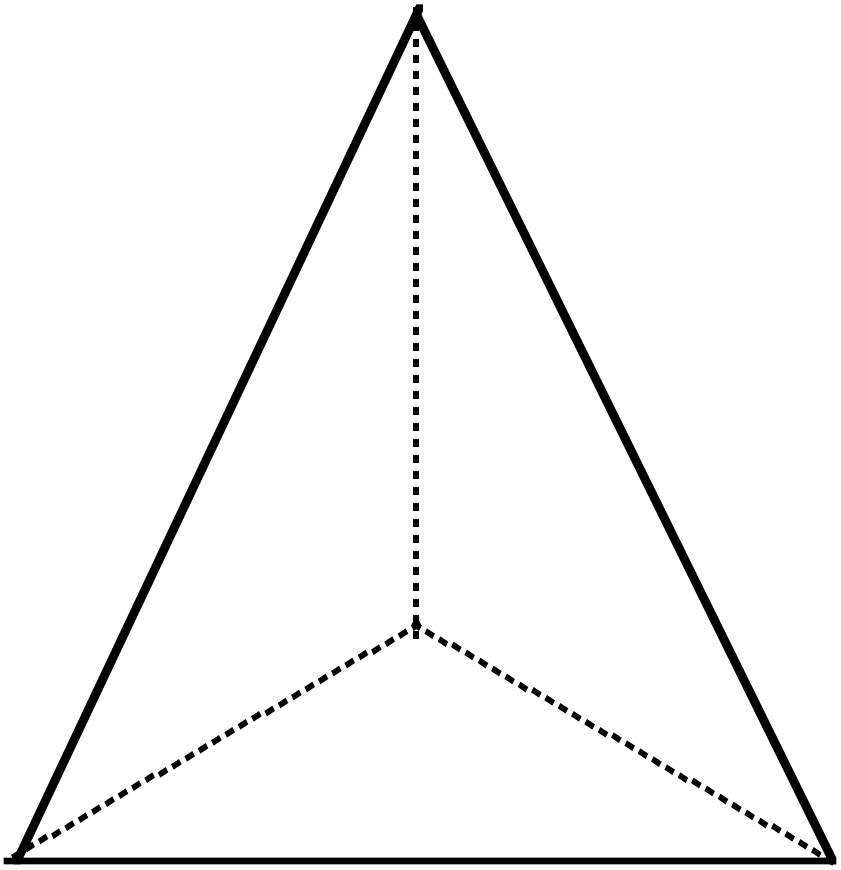


By lashing one figure on top of another, you can build a tower.

The top and bottom four joints of each section form squares. Put one section on top of another where these squares meet and lash them together at the points of contact.

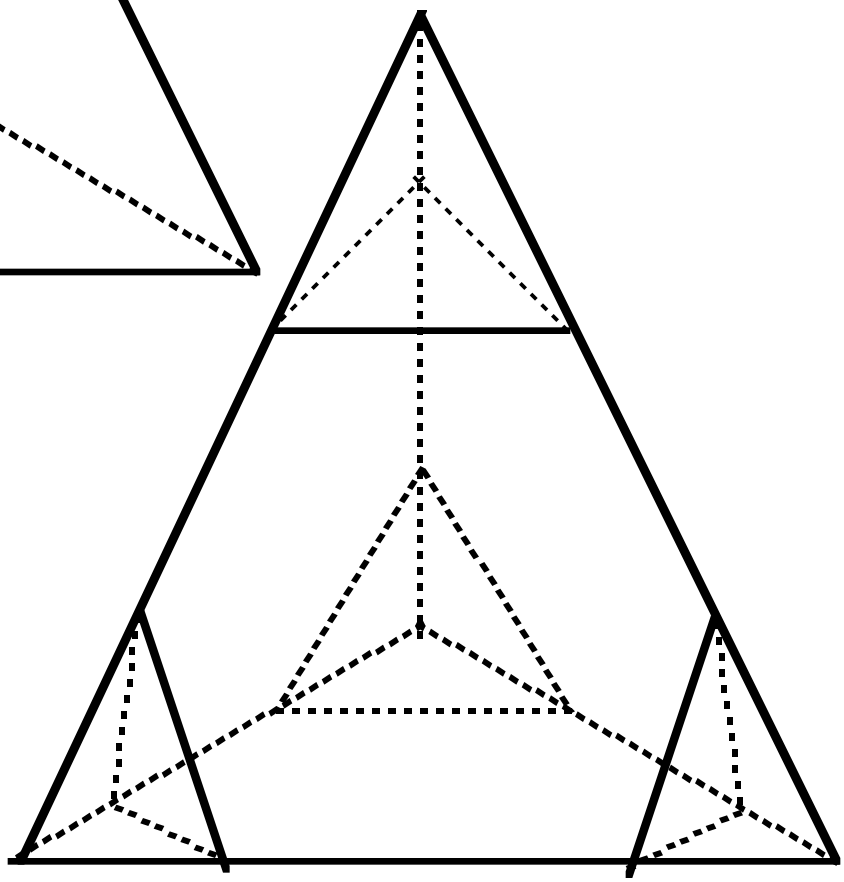
If you look at these models a certain way, you will see that, if you connect all the points with imaginary lines, there will be a regular geometric figure, with the spars acting like internal supports. Here's one example.

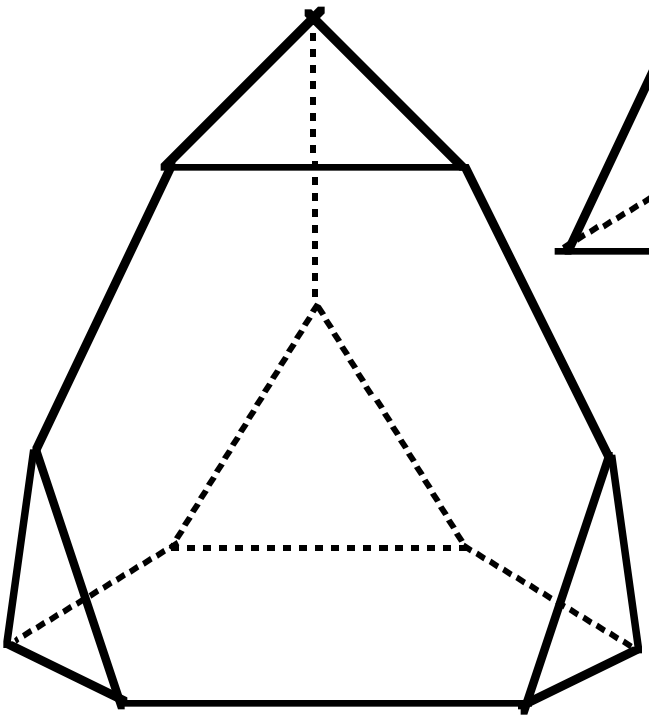
Take a pyramid (called a tetrahedron: tetra - meaning "four" and hedron - meaning "sides").



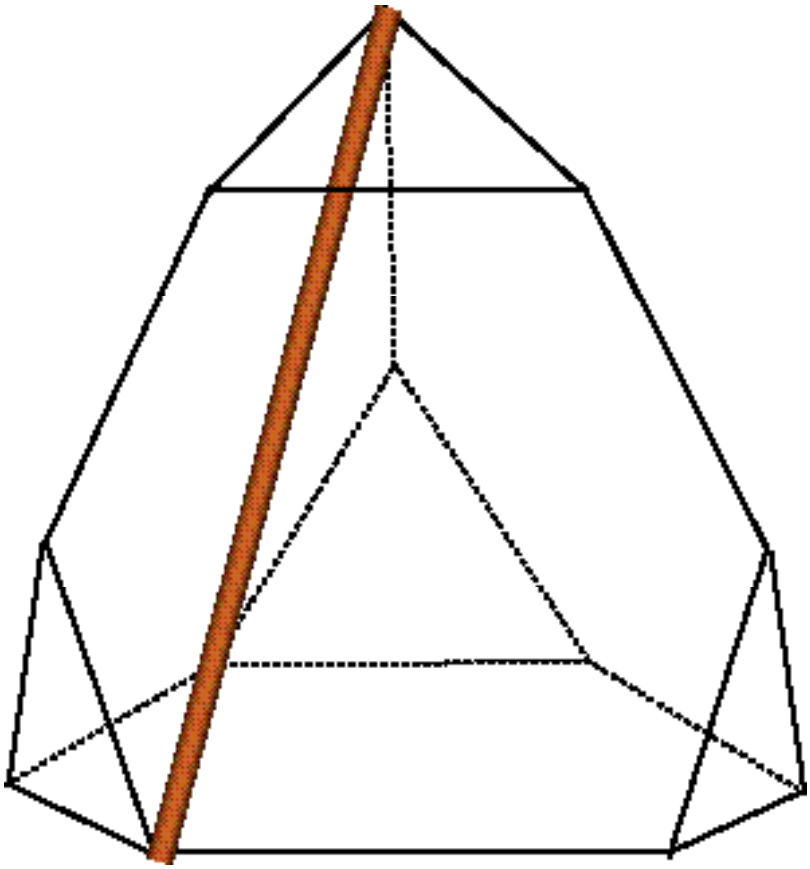
Now, pretend that you cut off each of the four points of the pyramid. That is called "truncating" the tetrahedron.

Now you have an eight-sided object with sides made up of four triangles and four hexagons (six sides). Can you see them?

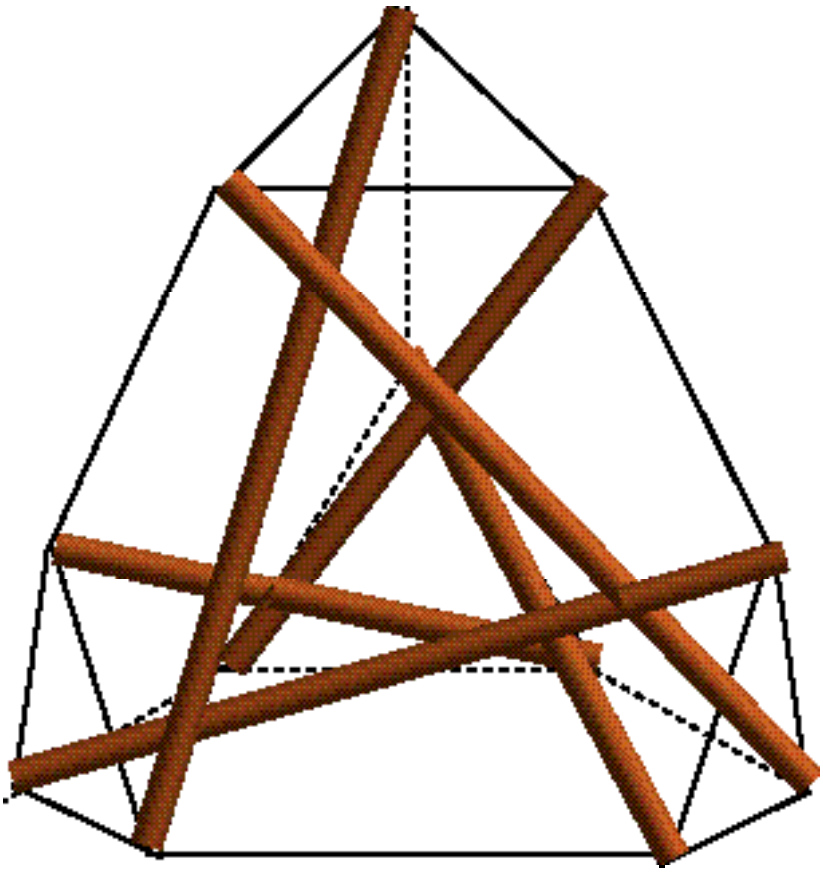




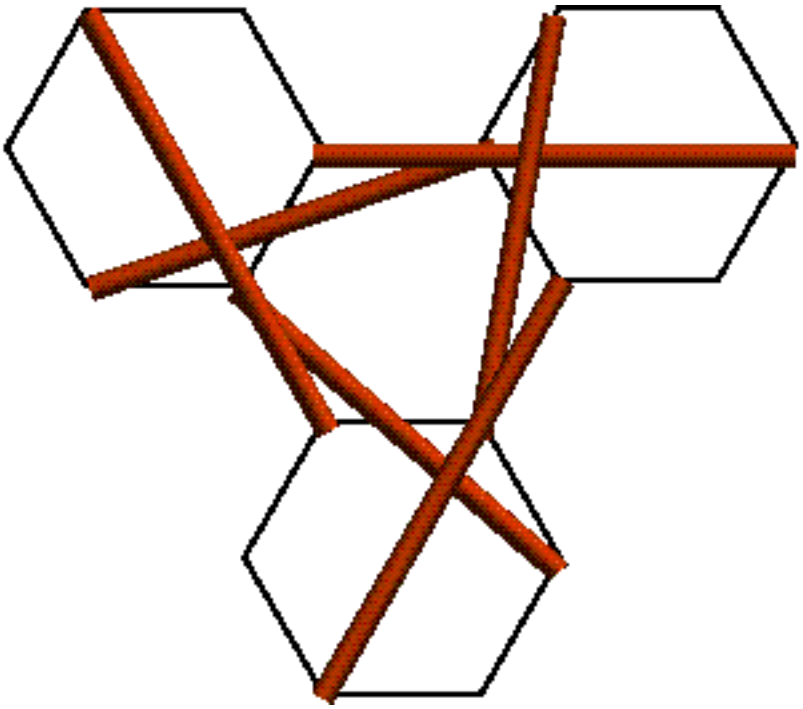
The remaining lines are where your ropes go.



The spars are placed with each end at the point of one of the triangles as shown.



When you are finished, this is how it should look. The ends of the spars each have three ropes attached. No spars will touch, and the model will stand on its own. If you use rope and strong spars to make this model, you will be able to climb on it!

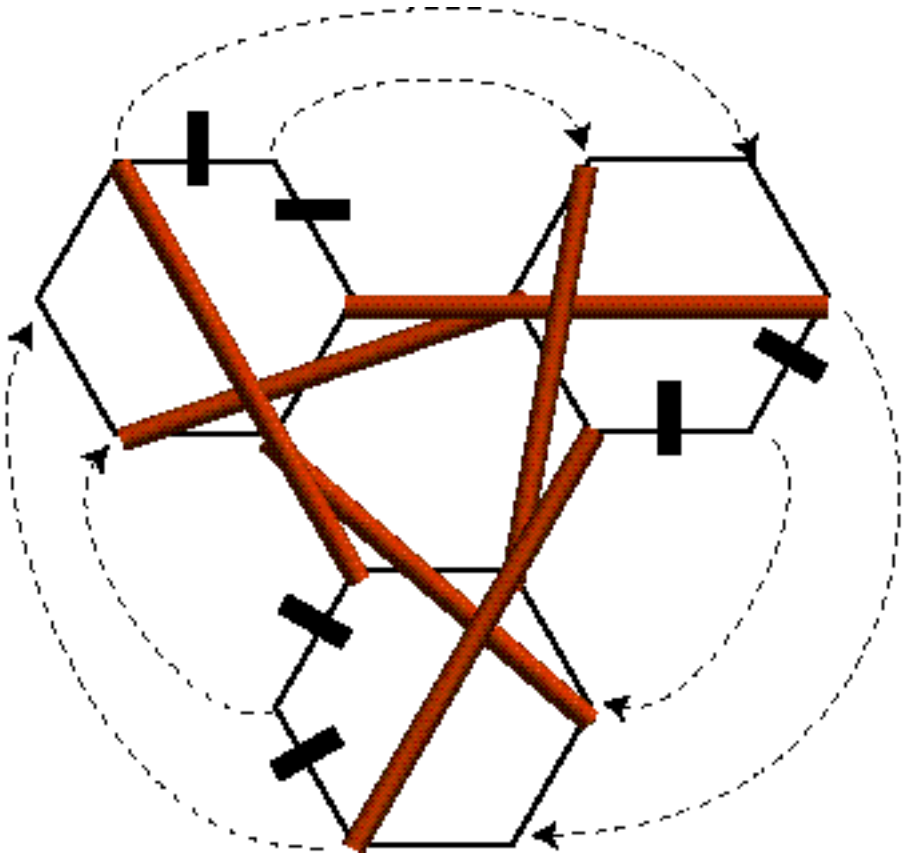


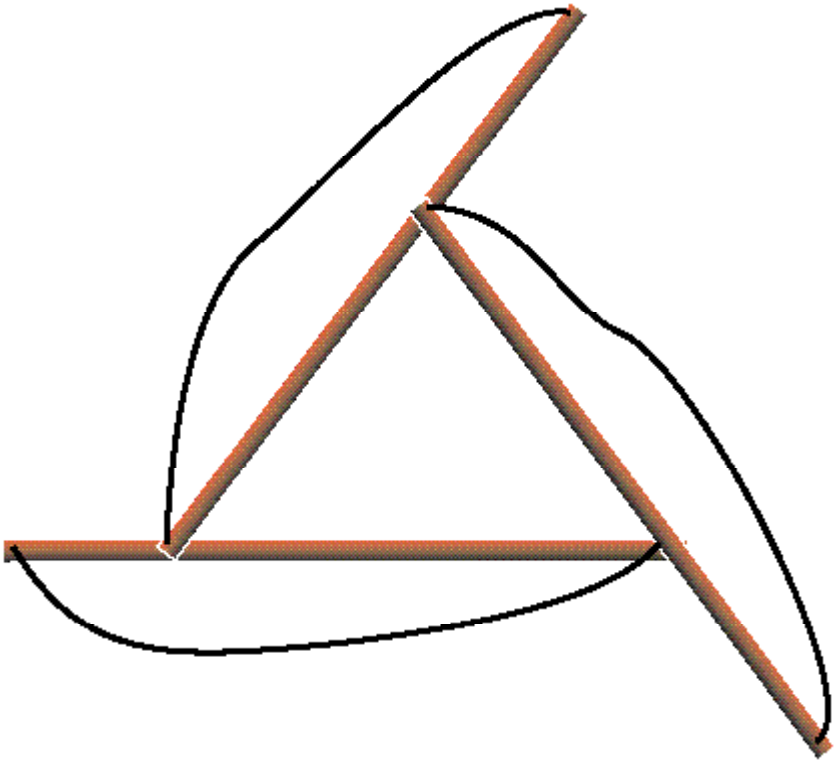
Here's another way to do it. Think of the line as forming four hexagons placed together as shown on the left. Where the hexagons meet, only one line is used.

Now lash six spars at the corners.

The lines should be under the spars.

Lift the three ends of the spars and lash them together at the top -- as shown by the arrows. You will notice that there are more double lines now (the ones crossed by the black bars). You can remove those too.



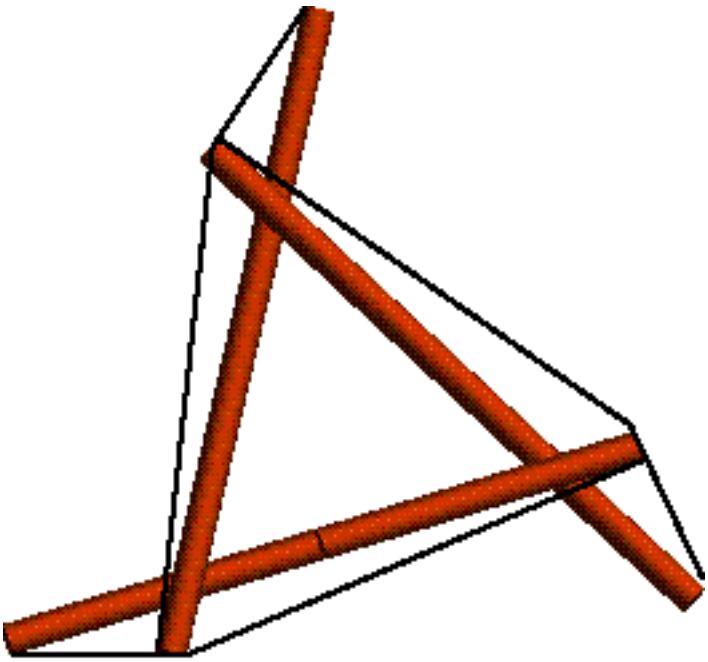


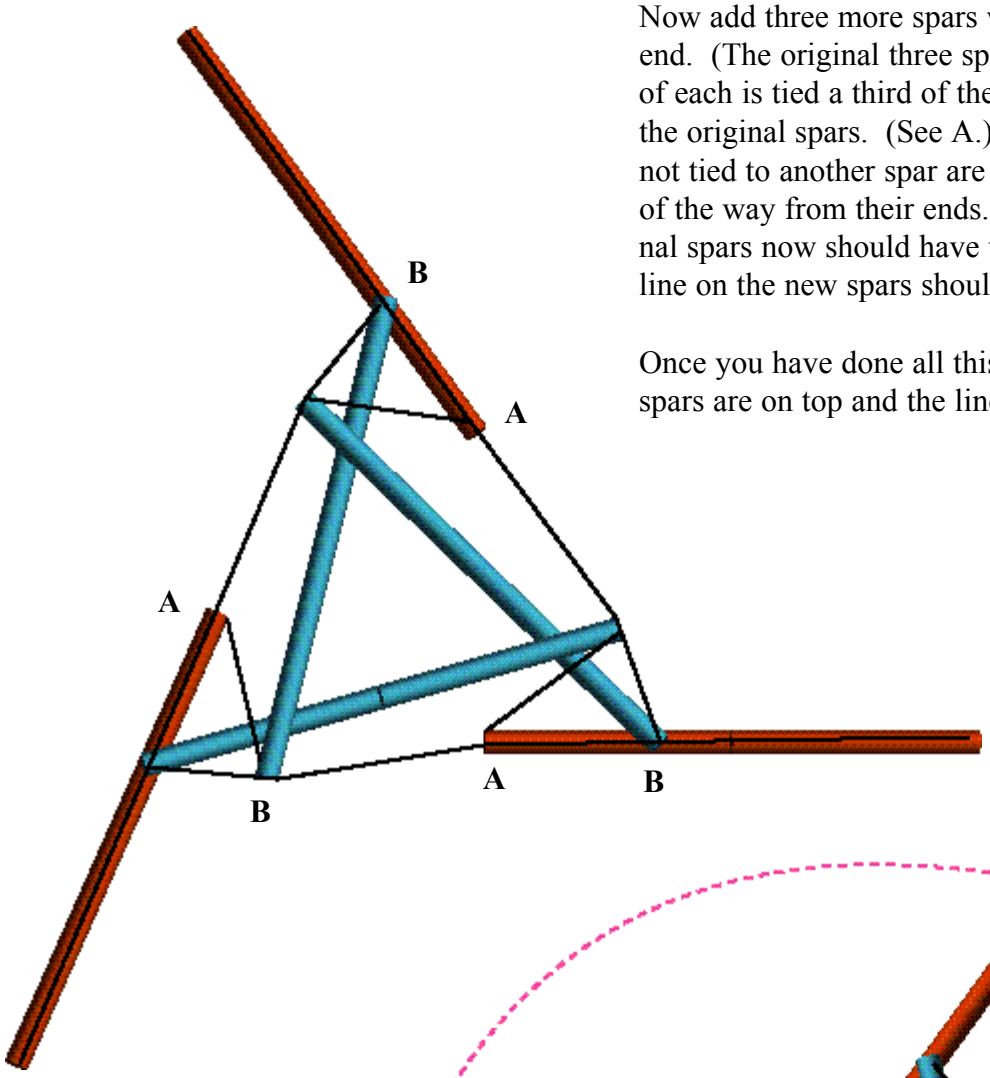
There's even a third way of making the same model.

Begin with three spars laid out as shown. Tie a loose line from one end to the other of each.

Tie one end of each spar to the line on the opposite spar, about a third of the way from its end.

Push the spars together until they look like this.





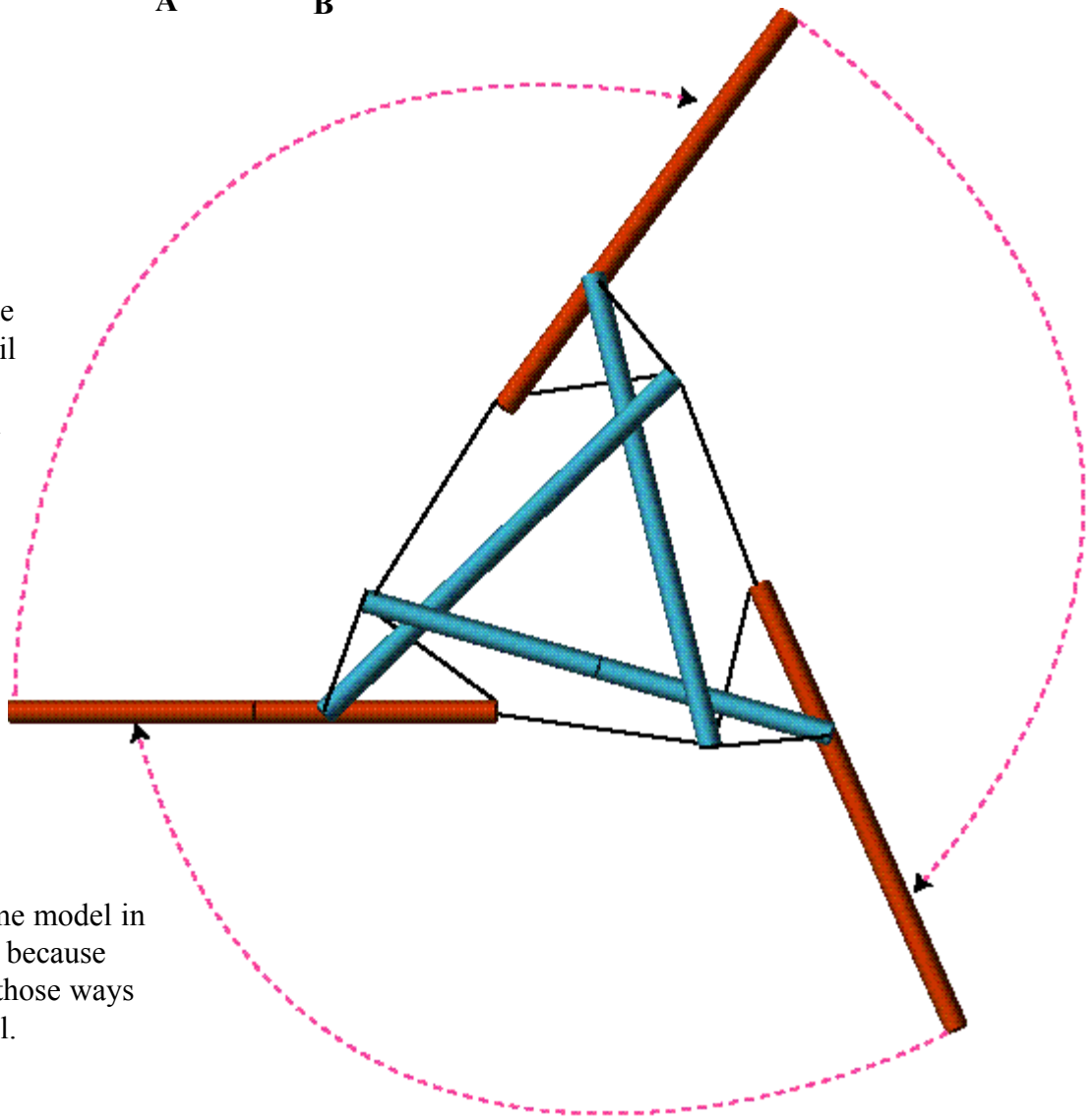
Now add three more spars with loose line tied from end to end. (The original three spars are shown in blue.) One end of each is tied a third of the way in from the end of one of the original spars. (See A.) The ends of the original spars not tied to another spar are now tied to the new spars a third of the way from their ends. (See B.) The line on the original spars now should have two other spars tied to it. The line on the new spars should have one spar tied to it.

Once you have done all this, turn the model over so that the spars are on top and the lines are on the bottom.

The last step is to raise the ends of the new spars until they reach the line of the other new spars as shown by the arrows.

Tie the ends of those spars to the lines a third of the way from their ends.

You should now have the same model!



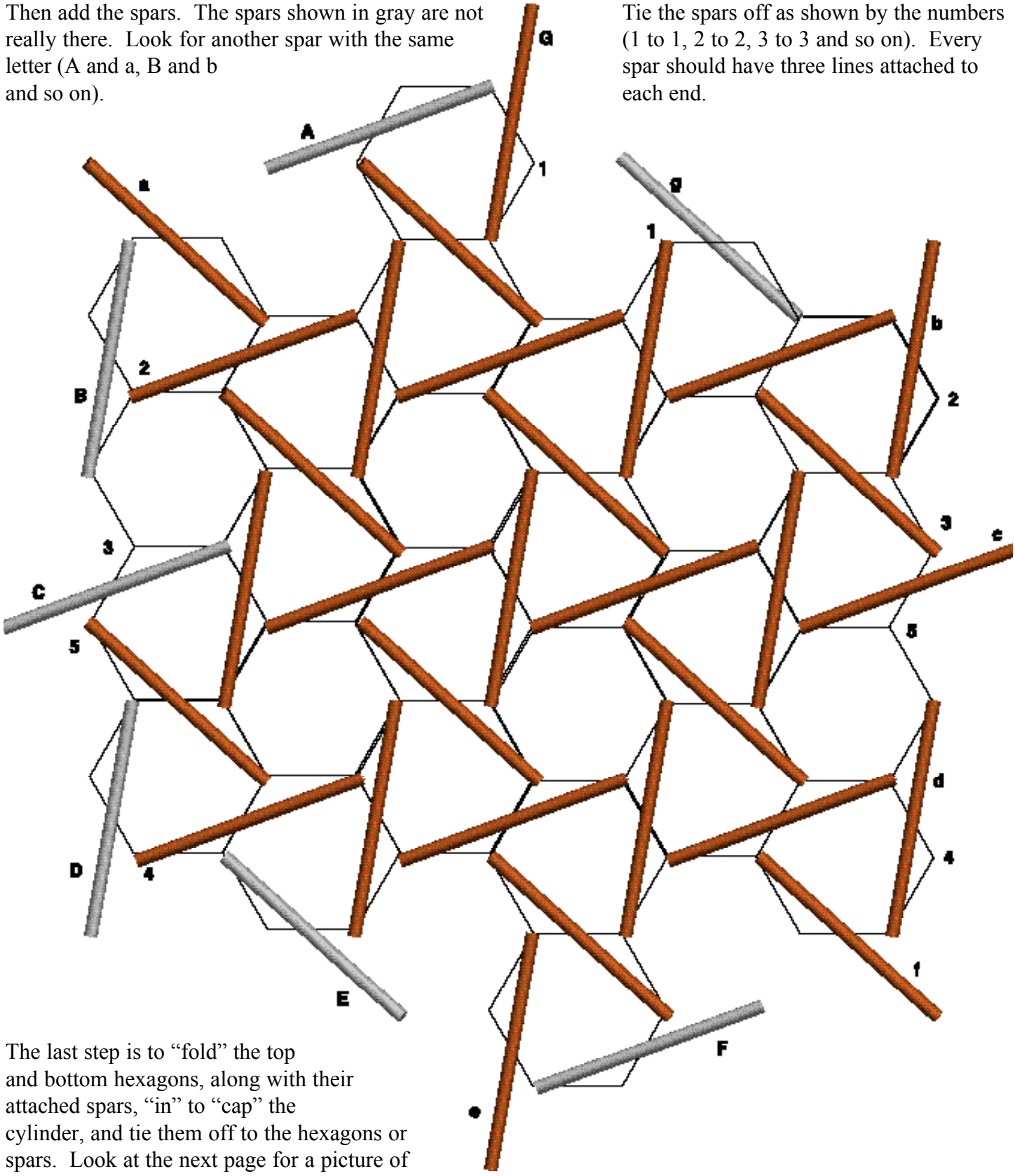
Why did we build the same model in three different ways? It's because we're going to use all of those ways together in the next model.

And here it is! It looks impossible to make, but you build it just the same way as before, only with more spars and line.

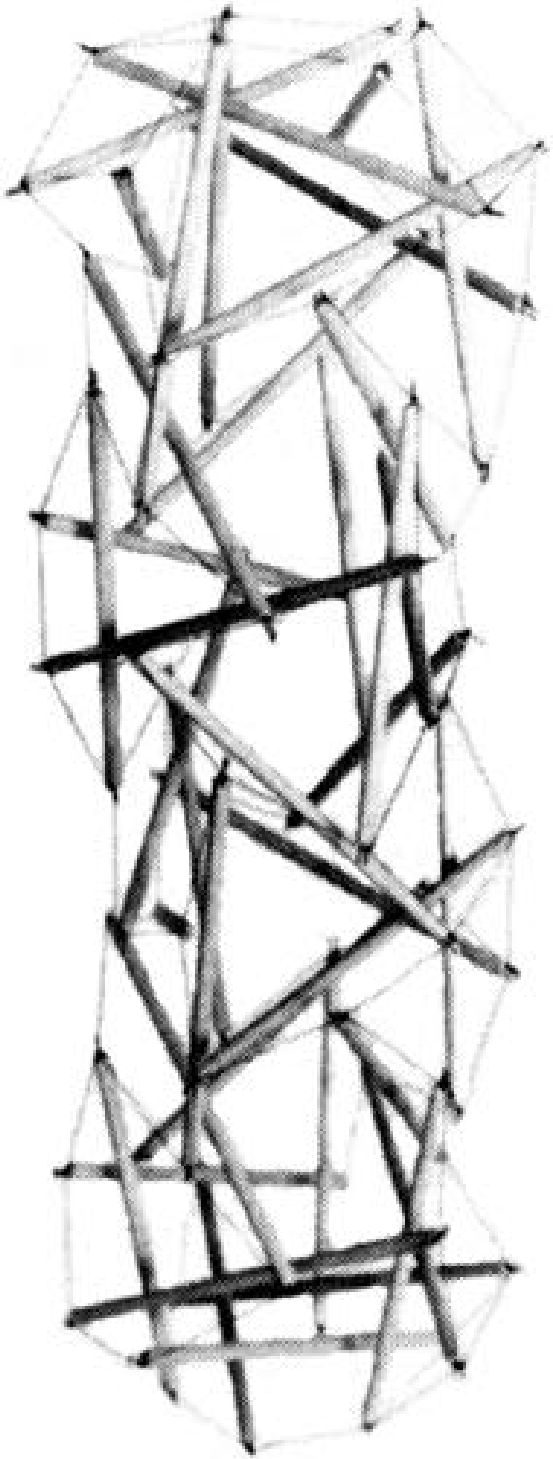
First ,lay out the line in hexagons.
Then add the spars. The spars shown in gray are not really there. Look for another spar with the same letter (A and a, B and b
and so on).

Once you've got all that done, flip the model so that the spars are on top of the line (as shown in this picture).

Bring the sides around to form a cylinder. Tie the spars off as shown by the numbers (1 to 1, 2 to 2, 3 to 3 and so on). Every spar should have three lines attached to each end.



The last step is to "fold" the top and bottom hexagons, along with their attached spars, "in" to "cap" the cylinder, and tie them off to the hexagons or spars. Look at the next page for a picture of what the finished model looks like.



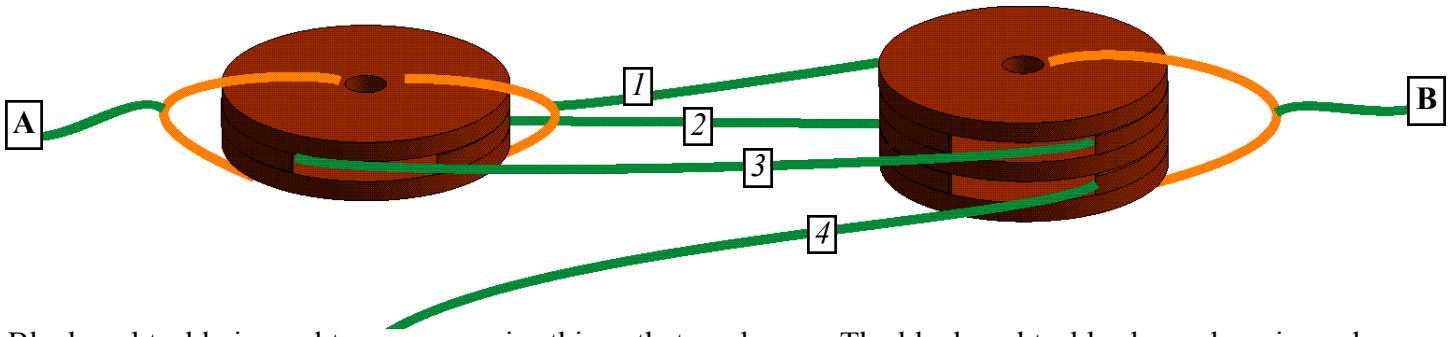
from Introduction to Tensegrity *by Anthony Pugh (University of California Press, 1976), with the permission of the publisher*

CHAPTER XII
USEFUL TOOLS

You don't need many tools to build most of the projects in this book. If you have to make your own spars, you'll need hatchets, saws and knives; but if you buy your spars, you'll need only a knife to cut the rope. Pulleys are needed in some of the projects. You can buy them or make them. That is true for other tools as well.

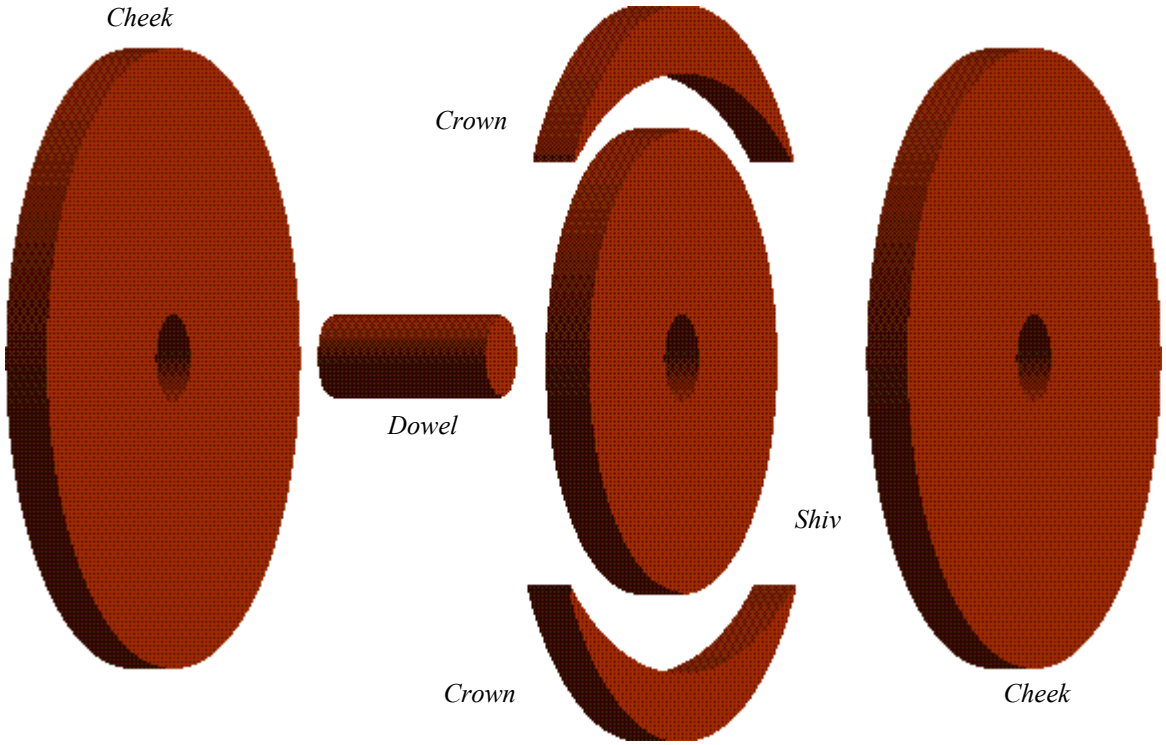
Block & Tackle

Courtesy of George Huffman

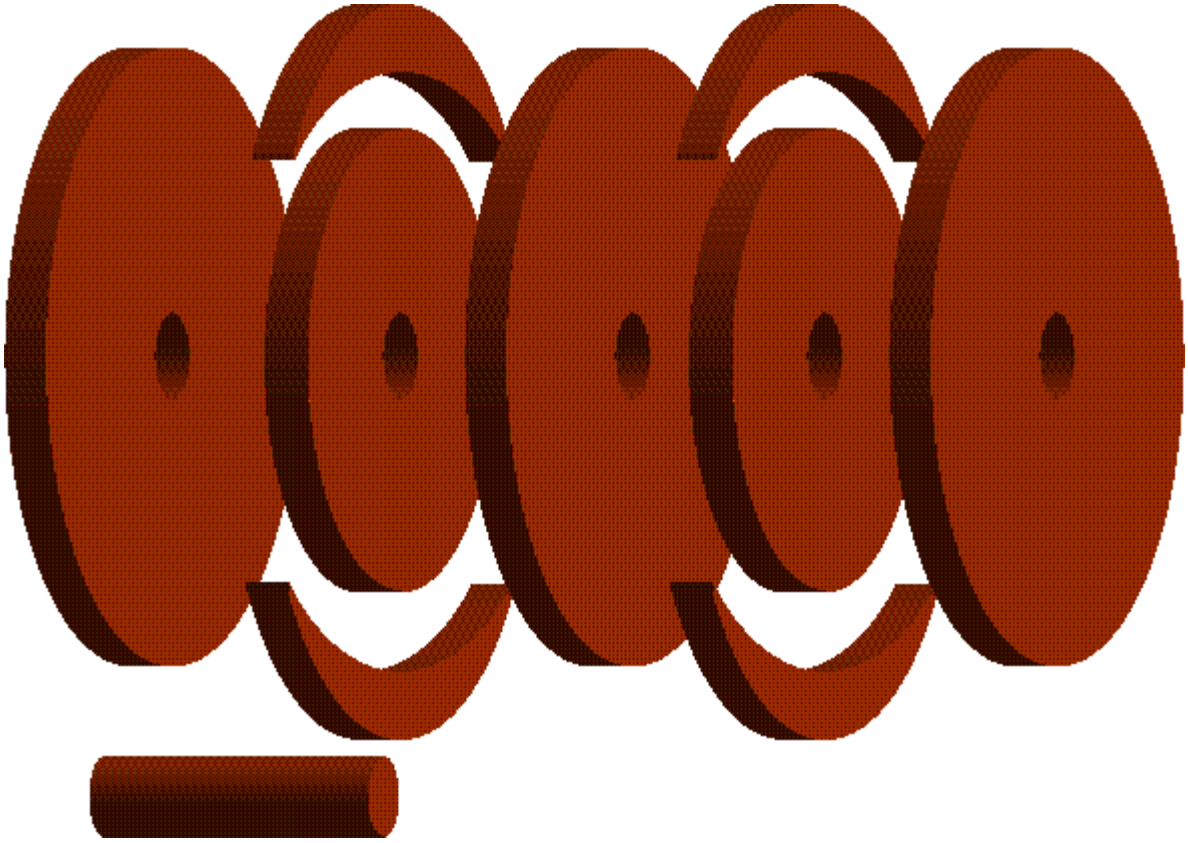


Block and tackle is used to move or raise things that are heavy. The block and tackle shown here is made up of two blocks or pulleys (a single on the left and a double on the right) and three lengths of rope. The ropes on the far left (A) and right (B) are tied to an object (left) and wherever you want to pull it (right). The rope in the middle is tied to the single block. It goes from there around the double block (1), back around the single block (2), then around the double block again (3). If you pull on the loose end (4), the two blocks are drawn together. Using the block and tackle, you can move or raise very heavy objects without a lot of effort.

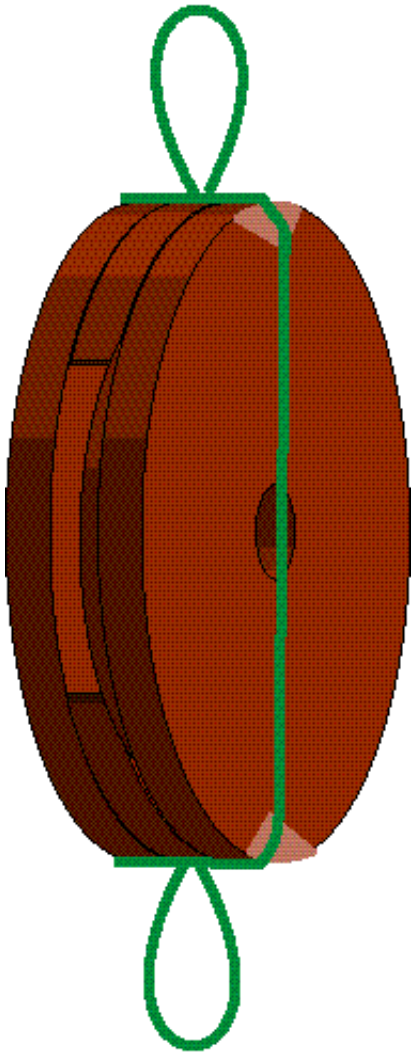
You can make your own block and tackle as shown here:



The two large disks (cheeks) are 4-1/2" x 3" x 1/2" thick, with a 1/2" round hole. The small disk (shiv) is a 3" circle, 3/4" thick, with a 1/2" round hole. The two crowns are crescents, shaped like the cheeks, but 3/4" thick. The dowel is 1/2" in diameter and at least 1-3/4" long. The whole thing is glued together and clamped until dry.



This is the double block. It has two more crowns and another cheek and shiv. All the dimensions are the same, except that the dowel needs to be 3” long.



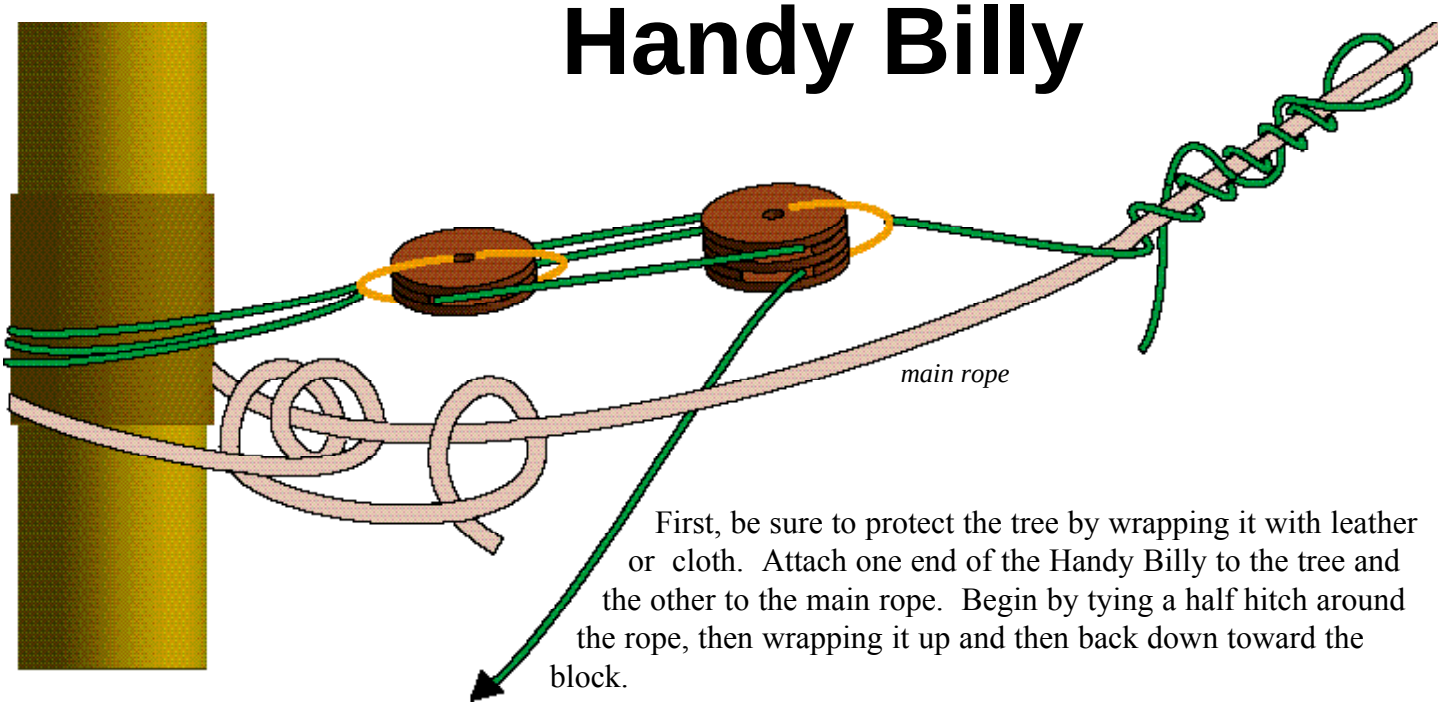
To make a harness that will let you attach the ropes, cut grooves in the edges of the cheeks and tie a rope around the block. A loop at the top and bottom of the harness gives you a place to attach the ropes.

WARNING!
These blocks are not meant to bear the weight of people. Use only metal blocks that you buy for that purpose.

Your block and tackle has many uses. You can raise or move heavy objects with it. Each time the rope passes around a pulley, the strength needed is halved. (Another way to look at it is that you double your strength.)

You also can use the block and tackle as a Handy Billy. With this tool you can hold and tighten a rope while attaching it to a stake or tree.

Handy Billy

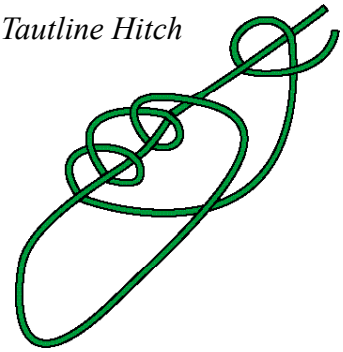


First, be sure to protect the tree by wrapping it with leather or cloth. Attach one end of the Handy Billy to the tree and the other to the main rope. Begin by tying a half hitch around the rope, then wrapping it up and then back down toward the block.

Leave enough (main) rope at the end to tie around the tree. Have someone pull on the Handy Billy until the rope is tight. Then tie the end of the rope around the tree using a tautline hitch and release the Handy Billy.

The Handy Billy is very useful when making bridges or for guy ropes that run from objects to stakes in the ground -- any line that needs to be especially tight.

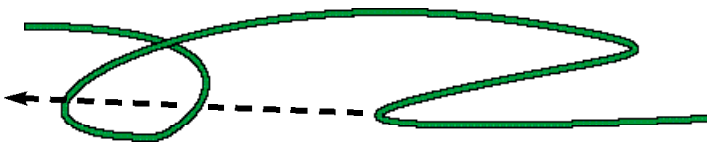
Tautline Hitch



To tie the tautline hitch, place the rope around the tree, and tie a half hitch. Then take another turn around the standing part of the rope. Finally, bring the running end of the rope above the double half hitch, and tie another half hitch on the standing part. You apply tension to the tautline hitch by sliding the half hitches up the standing part of the rope.

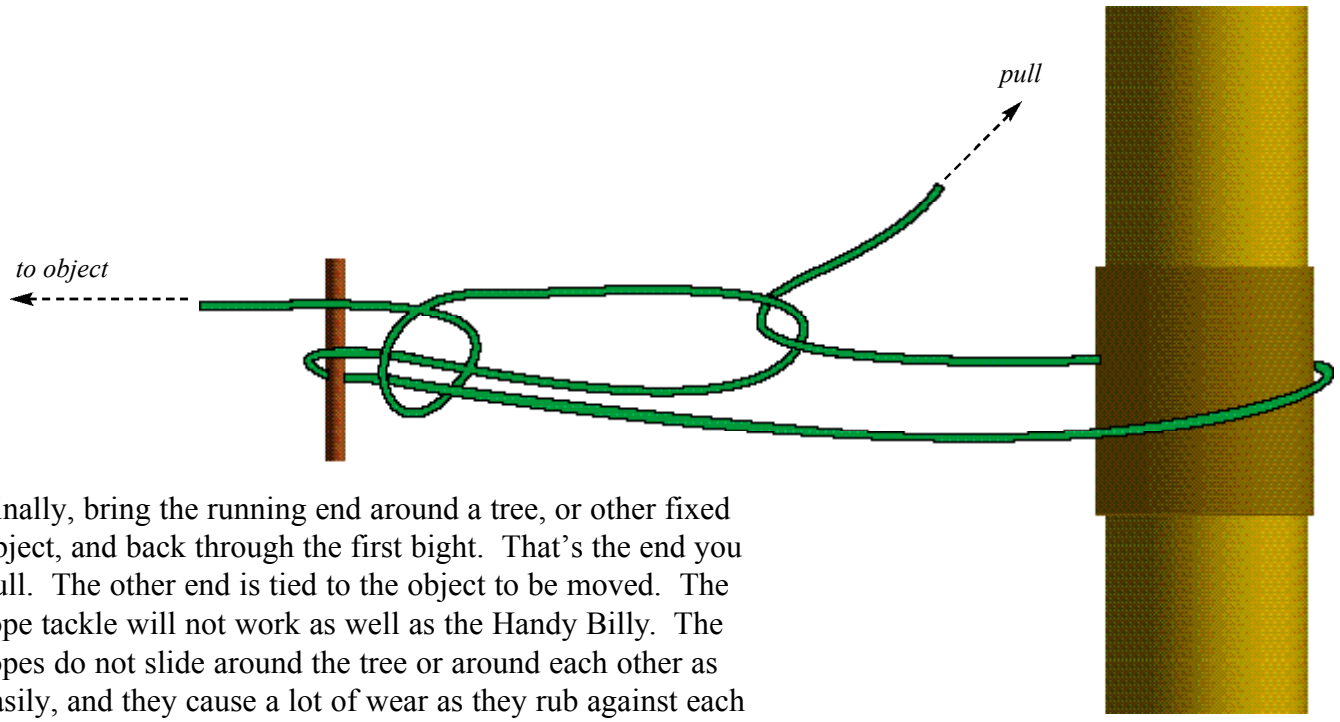
Rope Tackle

If you don't have a Handy Billy, you can make a rope tackle. It is not as easy to use as a Handy Billy and it is hard on your rope, but it will work.



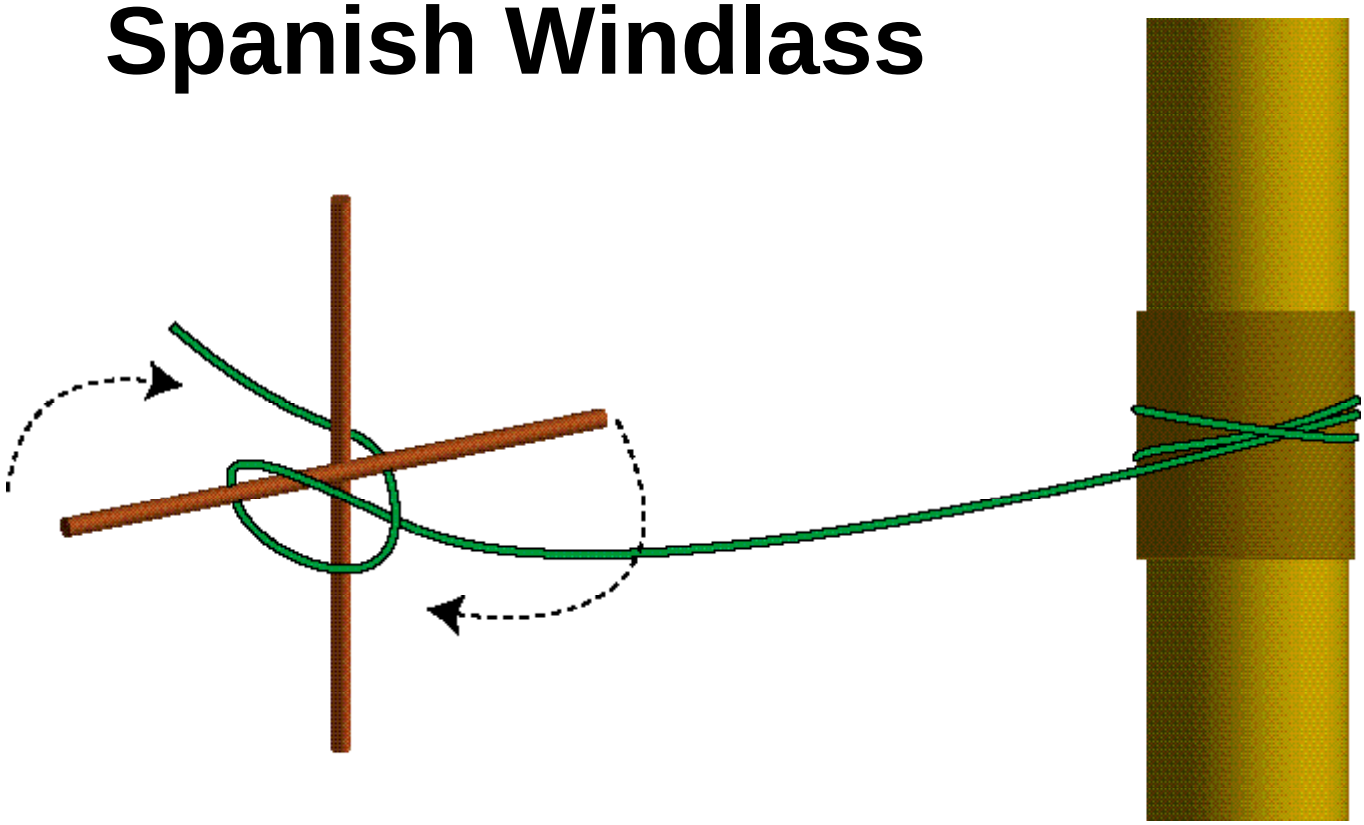
Begin, as shown, by making a loop in your rope, then make two bights in the running end, as shown. Put the last bight through the loop, which now becomes a half hitch around the bight.

Hold that bight in place with a small stake.



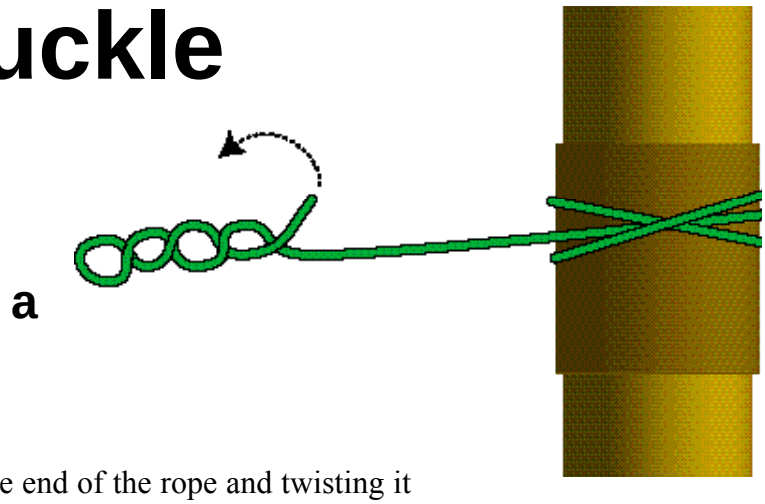
Finally, bring the running end around a tree, or other fixed object, and back through the first bight. That's the end you pull. The other end is tied to the object to be moved. The rope tackle will not work as well as the Handy Billy. The ropes do not slide around the tree or around each other as easily, and they cause a lot of wear as they rub against each other.

Spanish Windlass



Another way of moving a heavy object is with a Spanish Windlass. Tie one end of your rope to a padded tree or other solid object. Make the windlass with two spars as shown. They do not have to be lashed together, but the cross-spar must be "in front of" the upright spar. Bring the rope over and around the cross-spar, over itself and under the other side of the cross-spar. Attach the running end to the object to be moved. Two people stand on either end of the cross-spar and rotate it as shown. The rope will wind itself on the upright spar and become shorter. It will pull the object toward the tree.

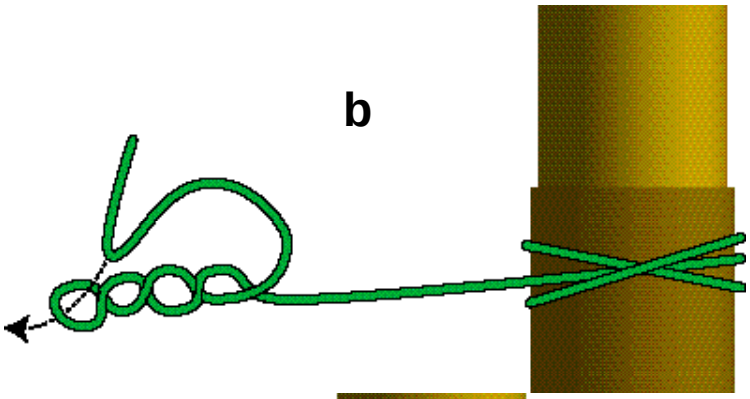
Turnbuckle

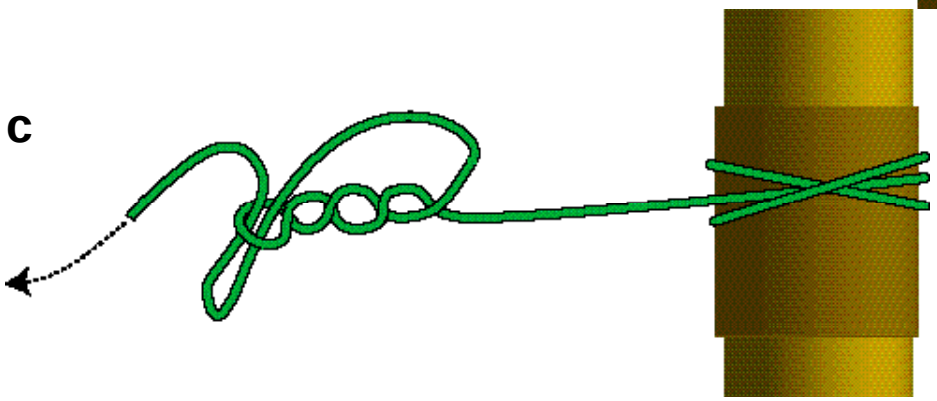


Any time you put a knot in a rope and put a strain on the rope, it weakens the rope. This is especially true with these "turnbuckles," as they are called. This knot is used by circus roustabouts to secure their big tents.

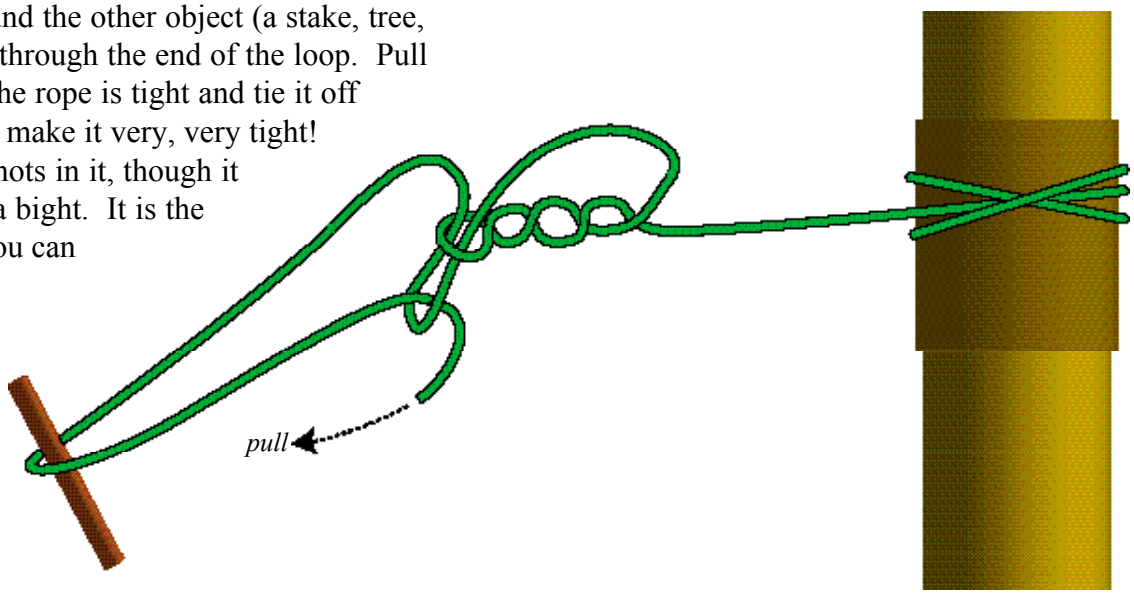
Begin by attaching one end of the rope and twisting it three times toward the middle (a).

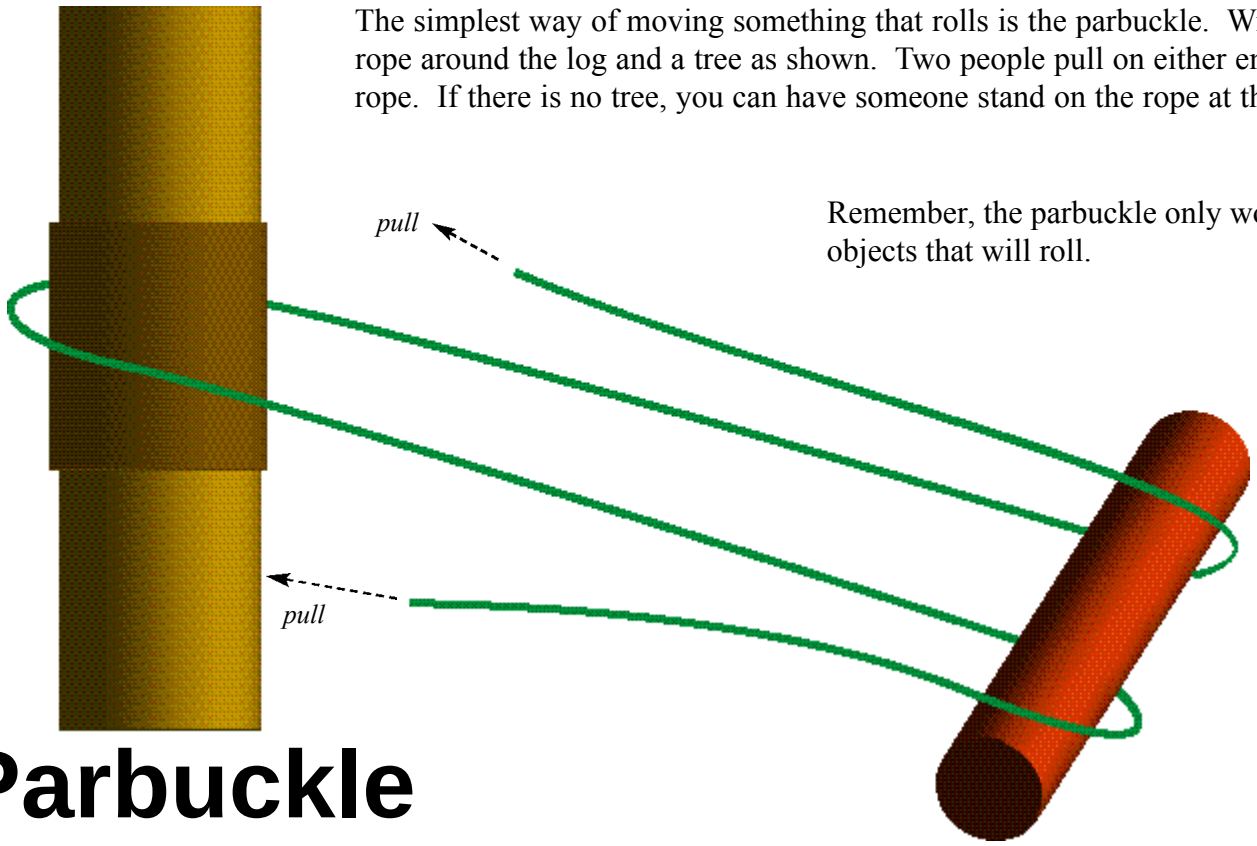
Make a bight in the running end of the rope, and pass it through the end of the twisted loop (b) to (c).





Now pass the end around the other object (a stake, tree, etc.) and bring it back through the end of the loop. Pull back on the end until the rope is tight and tie it off around itself. You can make it very, very tight! Notice that it has no knots in it, though it does have a twist and a bight. It is the strongest turnbuckle you can make without pulleys.



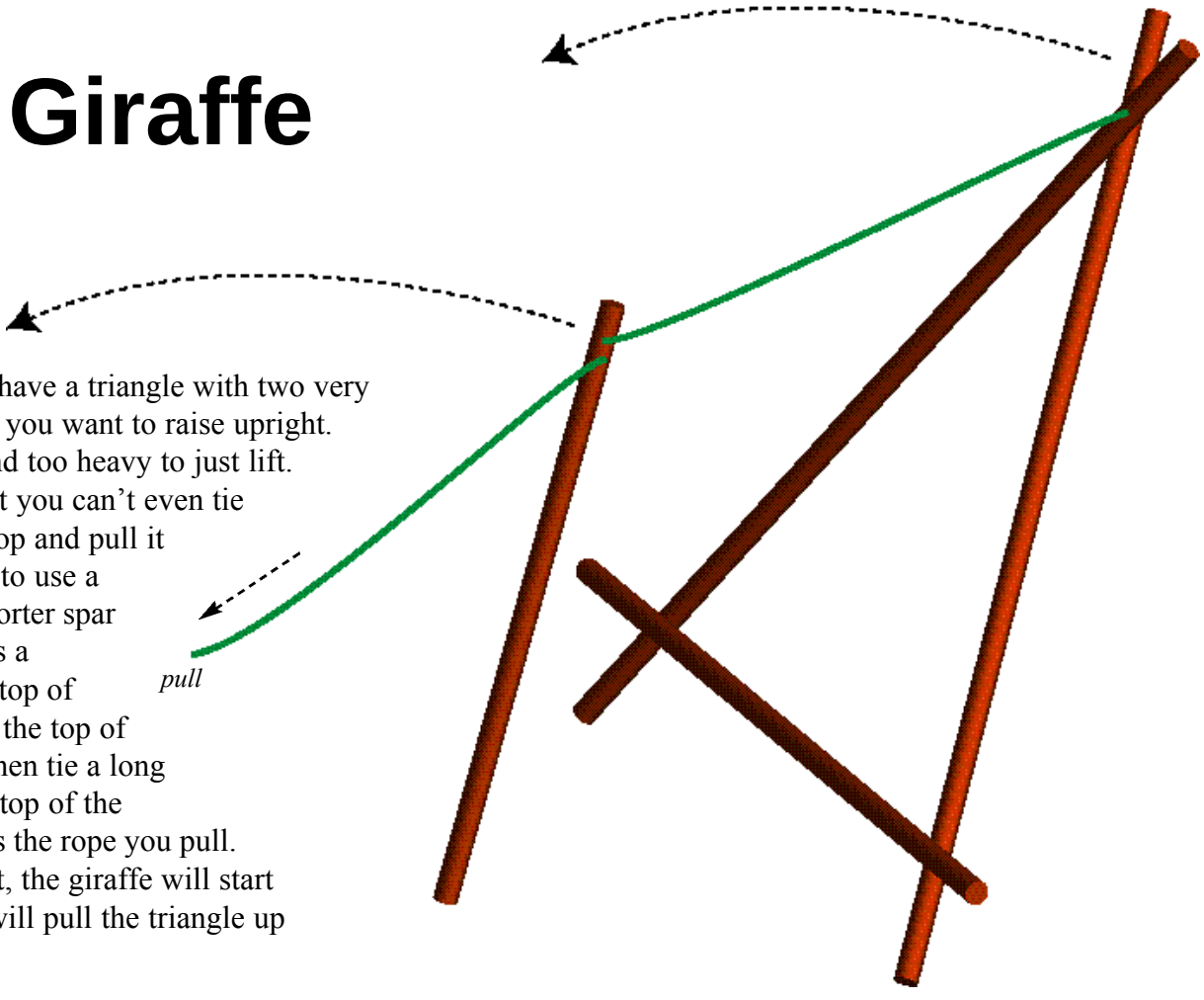


The simplest way of moving something that rolls is the parbuckle. Wrap the rope around the log and a tree as shown. Two people pull on either end of the rope. If there is no tree, you can have someone stand on the rope at that spot.

Remember, the parbuckle only works with objects that will roll.

Parbuckle

Giraffe

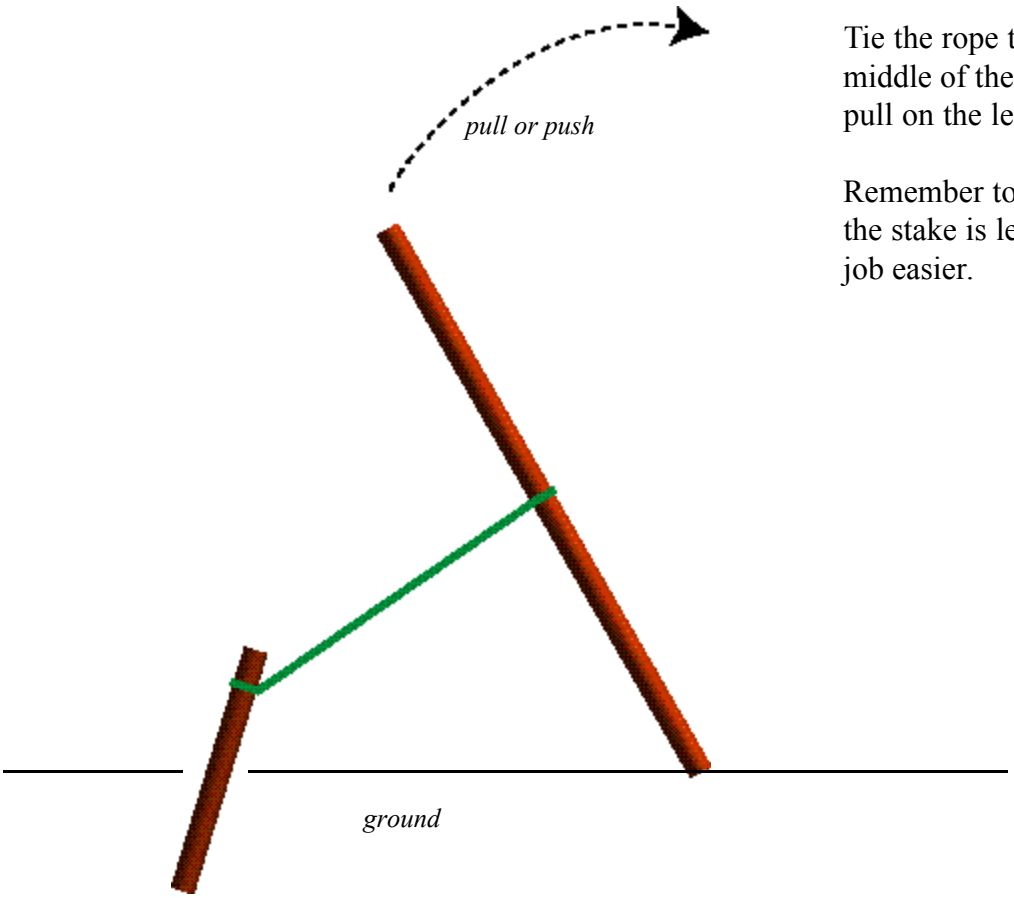


Let's say you have a triangle with two very long legs, that you want to raise upright. It is too tall and too heavy to just lift. It is so tall that you can't even tie a rope to the top and pull it up. You need to use a "giraffe," a shorter spar that you use as a lever. Tie the top of the triangle to the top of the giraffe. Then tie a long rope from the top of the giraffe. That's the rope you pull. As you do that, the giraffe will start to rise and it will pull the triangle up with it.

Levers and Pullers

Levers are very useful gadgets. They are used to increase your ability to move things. You can pry with them, push with them and pull with them. Here's an example of pulling.

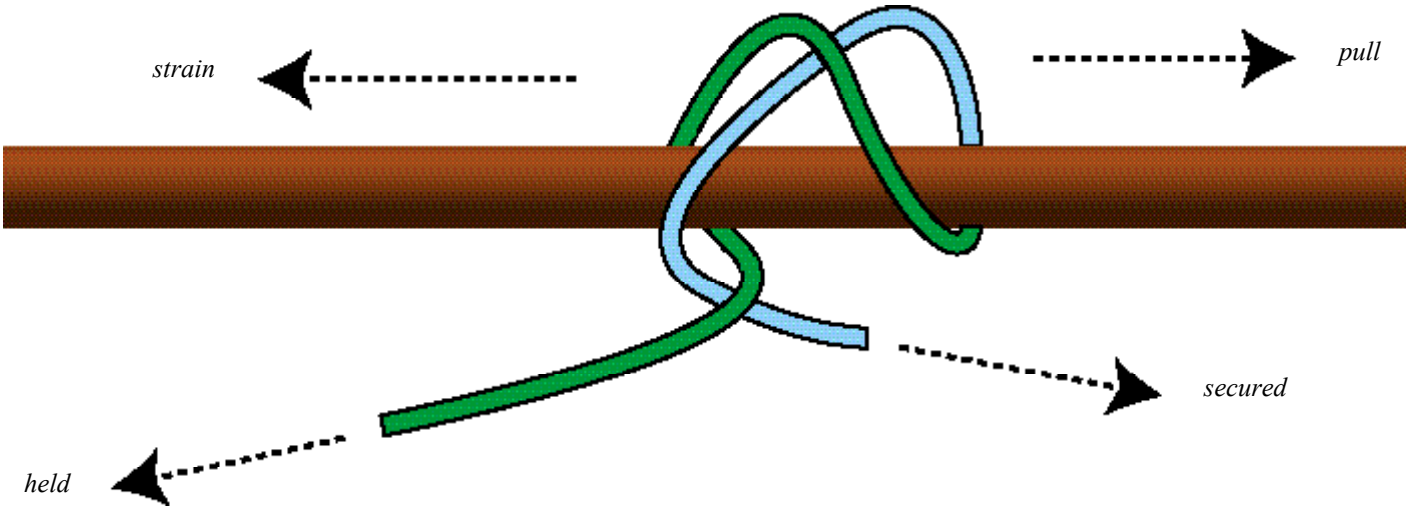
If you need to remove large stakes that you have pounded far into the ground, you can use a lever.



Tie the rope to the end of the stake and the middle of the lever. Then either push or pull on the lever to remove the stake.

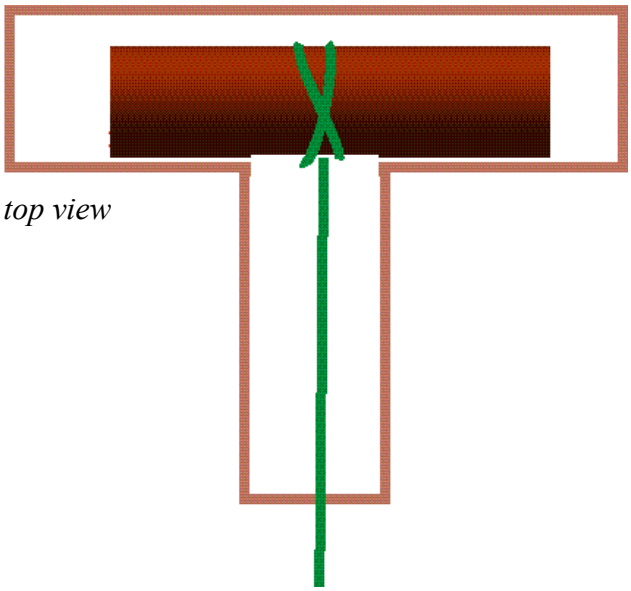
Remember to pull in the same direction that the stake is leaning. That will make your job easier.

Sometimes you can tighten a knot or loosen a spar by wrapping line around a small piece of wood that you use as a handle. For something with more uses try this line and spar puller:

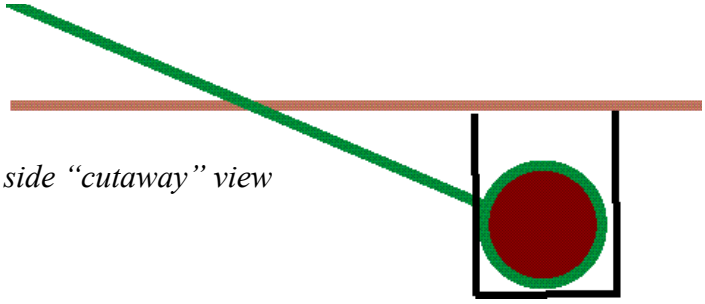


When you are building a large project that needs lots of support, a single stake may not be enough. You've already seen how to put several stakes in a row and tie one to another. Here are two more ways to make strong anchor points.

Deadman Anchor



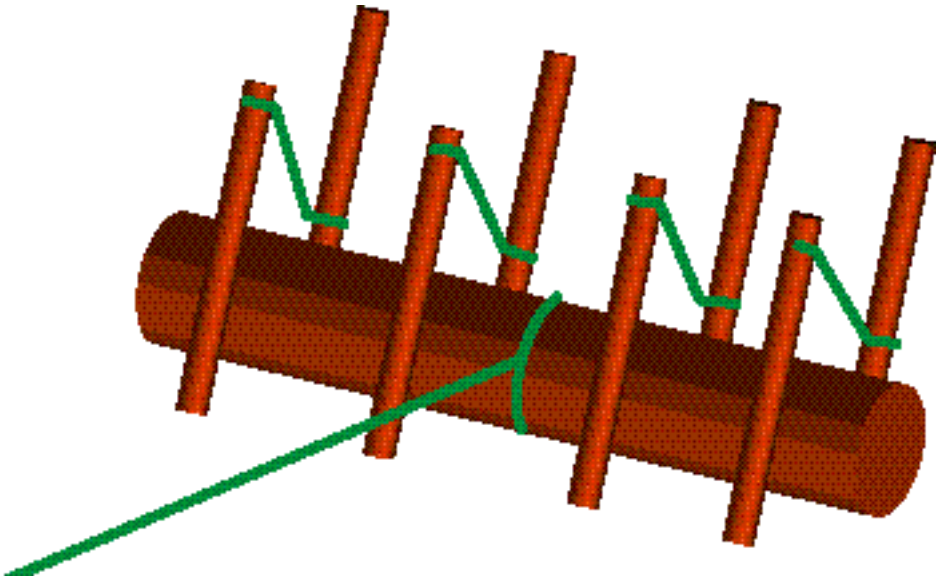
top view



side "cutaway" view

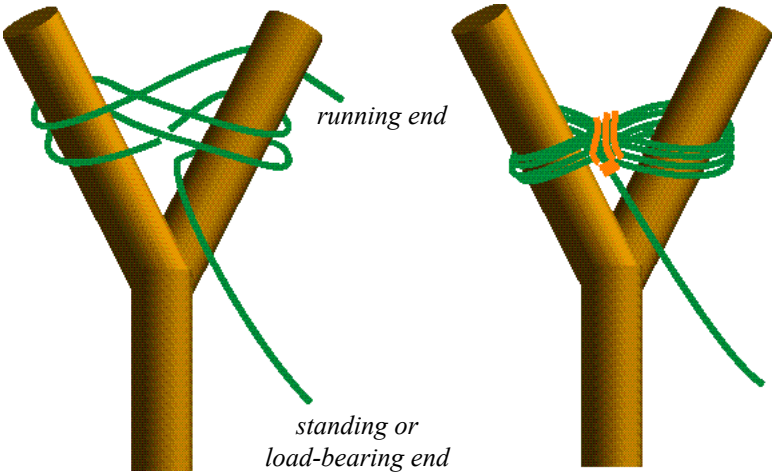
Dig a "T" shaped hole in the ground as shown in the top view. An anchor log fits in the cross-trench and the rope comes up out of the stem. Add stones or rocks to the hole in front of the log. This is very strong, but it damages the ground, so you can not use it everywhere.

Log and Picket



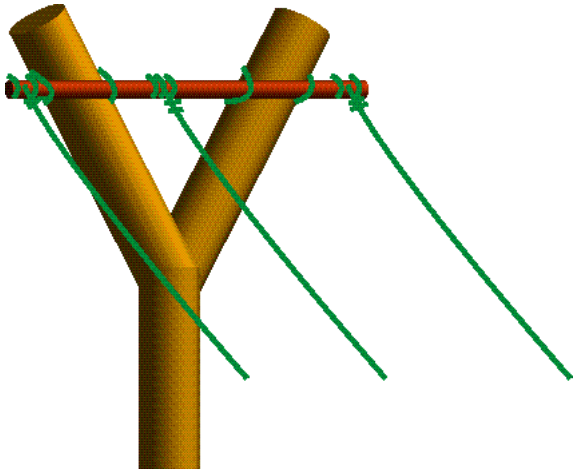
The log and picket is much better for the environment. Here you drive four sets of stakes, called "pickets," into the ground on either side of the log. Tie the lines from the tops of the front pickets to the bottoms of the rear pickets. The rope goes from the log to the structure.

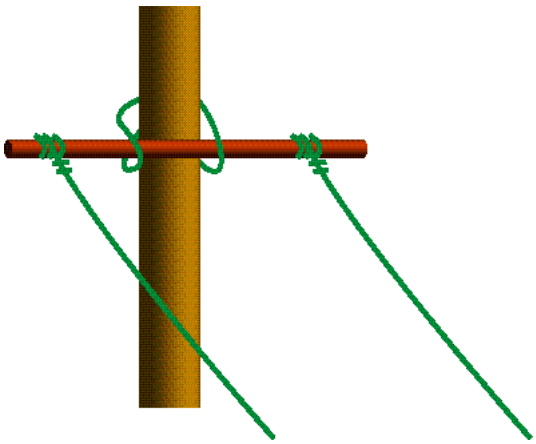
Tree Anchors



The anchor to the left is made by weaving a figure-8 across a fork in a tree. (Be sure to pad the branches well.) Wrap the running end several times around the "X" and on either side of the standing (load-bearing) end. Then take a couple of half hitches around the standing end to finish it off.

Another way of using a fork in a tree is to lash a spar across the "Y" (again, padding the tree). Then tie your line to the ends and/or middle of the spar.





If there is no forked tree, you can lash a spar across the tree trunk and tie the line at the ends. Be sure, however, that the strain on the lines is equal, or the spar will twist around the trunk.

I hope you have enjoyed this little book. There are many projects here to build, and it would take a long time to make all of them. But if you construct them all and want more to do, use your imagination or look for other sources in your library. The Boy and Girl Scouts and the World Scouting Movement have a lot of information on outdoors projects. They are called "pioneering projects" or "wilderness engineering." A series of books was published as part of the Scouting program in Great Britain by John Thurman and John Sweet. They include games as well as structures.

The PH projects are collected in a pamphlet published by the Programme Service of the Boy Scouts World Bureau (1972).

For Tensegrity Models, look for books by Richard Buckminster Fuller and Anthony Pugh. The general science is called *synergetics*. Also, there are kits to make Tensegrity Models for sale from Design Science Toys, Ltd., and even some web sites on the internet. Try the following: <http://www.lsi.usp.br/usp/rod/bucky/buckminster_fuller.html>, <http://www.teleport.com/~pdx4d/synhome.html> and <http://www.wnet.org/bucky.cgi>. The Needle Tower shown in Chapter XI is the work of Kenneth Snelson, who has constructed many pieces of art based on synergetic principles.